JANUARY 1957
In Two Sections—Section I

# ie

# ILLUMINATING ENGINEERING

*Journal of the*
ILLUMINATING ENGINEERING SOCIETY

## a new concept in low-cost, luminous beauty that affords greater freedom of architectural expression

**Here's a new** Benjamin lighting system, packed with possibilities. Its luminous beauty and choice of three designs make Sky-Liter the finest answer to today's quest for distinctively-lighted interiors.

Sky-Liter units are available for surface or recessed mounting. Choose from 2′ x 2′, 2′ x 4′ or 2′ x 8′ sizes, with 24″, 20-watt (Trigger Start); 48″ Rapid Start; or 96″ Slimline lamps. Special 2′ x 2′ translucent plastic panels efficiently diffuse the light. Panels are easily removed for lamp replacement or servicing, will not warp or discolor.

BENJAMIN ELECTRIC MFG. CO., DES PLAINES, ILLINOIS

Unique "Rattan" design in Vinylite (large illustration) enhances ceiling beauty with its unusual pattern, while the "Saxon" features down-to-earth simplicity in distinctive Plexiglass.

The distinctive beauty of the new "Safari" design emphasizes the great versatility of the Sky-Liter System. For added variety, recessed or surface-mounted units may be installed individually, in tandem, parallel or at right angles to achieve any geometric design.

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*Sylvania's VHO lamp makes possible more light per foot from fluorescent lamps*

# Produces more than twice the light output of conventional 40 watt lamps!

**Sylvania Research conquers Heat and Pressure—two major obstacles to more light per foot!**

**The VHO-lamp represents an entirely new concept in lamp design—an entirely new way to get more light per foot from fluorescent lamps.**

**To make this achievement possible Sylvania engineers have developed and combined these vital features:**

**1. New "Pressure Control" Center. The specially developed, exclusive internal end construction of the VHO lamp creates "cool spots" at each end which allow mercury to condense.**

**2. Neon gas replaces Argon. Sylvania discovered that Neon actually gives far greater efficiency at higher wattages than the conventional Argon.**

**3. Use of standard T-12 bulb. The popular T-12 bulb permits maximum effective production and use of ultraviolet radiation within the tube.**

**4. The Patented Sylvania Rapid Start System. This development for fluorescent lamps keeps filaments warm during operation of lamp, and encourages effective electronic emission from filaments at all times.**

IN APPEARANCE, the VHO-25 is a standard 4-foot T-12 lamp, yet it produces *more than double* the light output of 40-watt fluorescent lamps made until now.

Due to the substantially greater light output of the Sylvania VHO, High-Bay Industrial Fluorescent lighting becomes practical and economical. In Low Bay lighting, VHO lamps will, in many cases, prove more economical because fewer fixtures are required.

VHO lamps are also a new and practical answer to better, highly efficient street lighting . . . use a minimum of lighting units of less cumbersome size. They are also particularly suitable for other outdoor lighting applications such as store fronts, service stations, and floodlighting of outdoor industrial or commercial areas.

If you are considering plans which include lighting for new construction or modernization, the new Sylvania VHO fluorescent lamp will be of particular interest to you. For complete details consult your local Sylvania Representative, or send today for your free folder about the revolutionary Sylvania VHO Rapid Start Fluorescent Lamp. Write to:

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**STARRING & COMPANY, INC.**

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# ILLUMINATING ENGINEERING

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January
1957

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In Two Sections
Section 1

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ADVANCE fluorescent lamp ballasts are synonymous with *Efficiency, Endurance, Economy*. ADVANCE ballasts are the result of extensive engineering, research and precision manufacturing methods, enabling us to produce in volume the most complete line of fluorescent lamp ballasts in the world . . . and back each ballast with a two-year guarantee. Whether you manufacture, specify, install or maintain fluorescent lighting make ADVANCE your Silent Partner and be assured of the most efficient, longest lasting, economical fluorescent lamp ballasts you can use.

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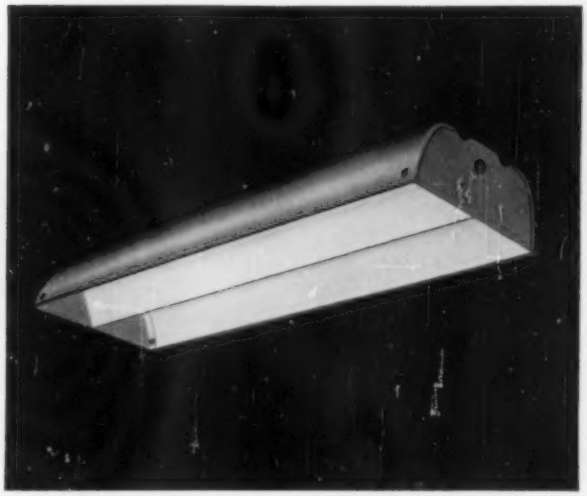
## *with Curtis 6000 Industrial Series Luminaires*



■ "Tunnel-effect" lighting, common in industrial areas, is a condition of high brightness ratios and annoying glare, causing the eye-strain and fatigue that's responsible for low efficiency and many accidents.

Curtis 6000 Industrial Series luminaires eliminate those "tunnels" by providing a 25% up-light component, with 75% of the light output placed on the work surface.

With Curtis 6000 Industrial Series luminaires, there's a wide selection of equipment to choose from so that every requirement and condition is easily met.

### FINISHES

Curtis 6000 Industrial Series luminaires have side reflectors of:

- Alzak processed high purity grade aluminum, a non-tarnishing, non-corroding lifetime surface that's easily maintained.
- white porcelain enamel on enamelling iron, a smooth and durable finish.
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### LAMPS

Curtis 6000 Industrial Series luminaires can accommodate all 4', 5' and 8':

• Slimline Lamps • Rapid Start Lamps • High-Output Rapid Start Lamps • Starter Type Lamps

### INSTALLATION

Curtis 6000 Industrial Series luminaires can be installed in many ways, all of them fast, easy and economical.

- Curtis patented "Tong" Hangers clamp anywhere on the channel, by-passing all building obstacles, and it's designed to clamp at the juncture of two units, the only "Tong" hanger of its kind.
- Curtis Wire Entrance Hangers have fast slip-over type hickeys that save time and money.
- And Curtis 6000 Industrial Series luminaires can be chain suspended or installed on messenger cables.

These are only a few of the reasons for using and specifying Curtis 6000 Industrial Series Luminaires. Send the coupon for specifications and remember, with Curtis 6000 Industrial Series luminaires, there are no more "tunnels" of light.

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The patterns the fixtures comprise are extremely interesting while providing even lighting of the merchandise. (Excellent for retail sales — particularly "impulse" purchases.) The fixtures themselves are Litecontrol's No. 7724RS 2 lamp surface baffle type and they make this drug store's lighting dollar go a long way.

We've had a lot of experience in designing and manufacturing fluorescent fixtures for lighting and relighting stores, schools, offices, banks and factories. It is very probable that you will find the solution to a lighting problem right in our catalog.

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GENERAL CONTRACTOR:
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ELECTRICAL CONTRACTOR:
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INTENSITY:
75 footcandles in service.

LITECONTROL *Fixtures*

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# Lighting Progress in 1955-1956

**Prepared by the Committee on Progress of the Illuminating Engineering Society**

This Committee is pleased to report, in pictorial form, developments in lighting which were considered interesting and new, with no attempt to judge whether good or bad.

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## Sources Have Changed

**Figure 1. Electroluminescence has become bright enough for moving picture photography with ten lumens per watt and up to 1700 footlamberts. Color is now controllable by frequency change and by phosphor selection; the brightness by voltage.**

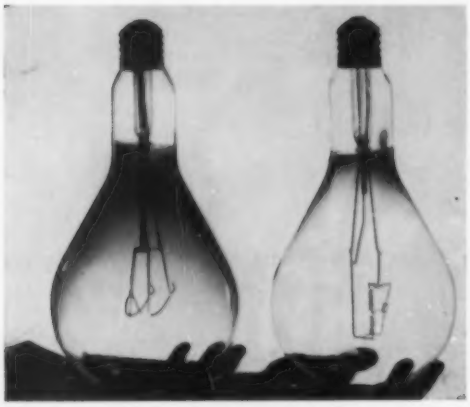


Figure 2. The vertical positioning of a coiled-coil filament improved initial lumen output and increases lumen output throughout life.

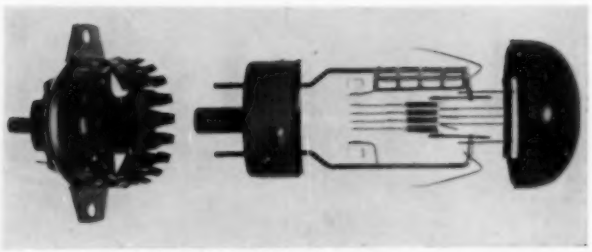


Figure 3. Low contour projectors are possible due to new types of projection lamps with base and socket construction which permits either horizontal or vertical positioning of the bulb.

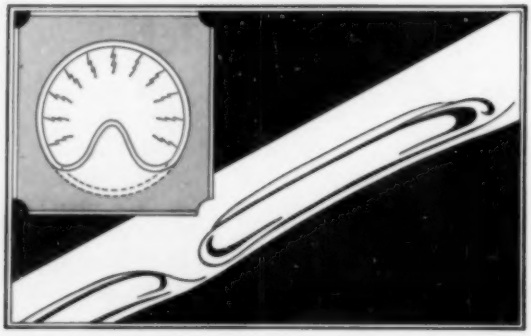
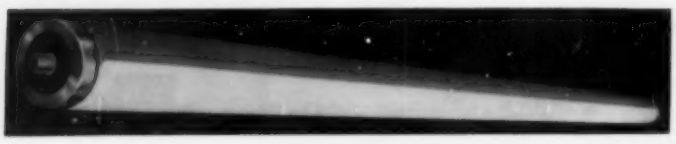


Figure 4. (left and above) Eight-foot rapid start lamps in at least two styles are now rated as high as 200 watts. The trend toward higher lumen output per foot of lamp length continues, bringing new intensity levels to fluorescent types for many uses.

Figure 5. (left) A recent addition to the 1000-watt mercury vapor line is a new color improved lamp with phosphor coating over the base half of the bulb. Utilizing the phosphor as a reflector as well as for color improvement results in about two-thirds of the light directed downward. Reflector efficiency is higher and maintenance is better, while brightness at high angles is reduced.

Figure 6. (below) A partial reflective coating inside the tube of this new type fluorescent lamp gives directional character to light emitted. Accumulation of dirt on lamp and reflector surface has little effect on light output.



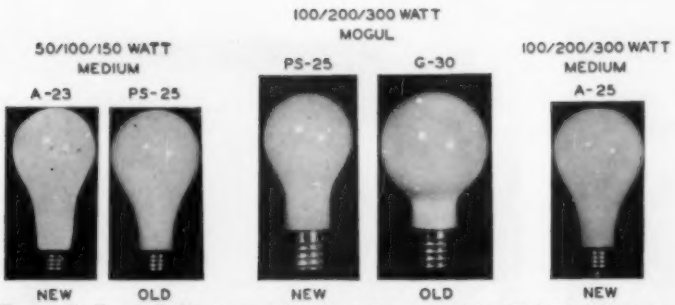



**Figure 7. Lamp bulb size continues to decrease. The 50/100/150-watt medium screw base lamp has been changed from PS-25 to A-23 bulb size; and the 100/200/300-watt lamp from G-30 mogul base to PS-25 mogul base. A new lamp, shown at right, comes in the A-25 bulb size. The "three-speed" lamp line also has a 30/200/230-watt addition, not shown, in the PS-25 bulb, medium screw base.**

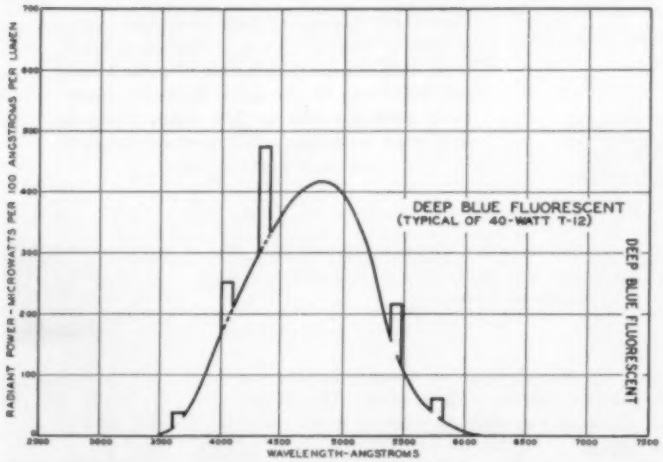

RADIANT POWER - MICROWATTS PER 100 ANGSTROMS PER LUMEN
DEEP BLUE FLUORESCENT
(TYPICAL OF 40-WATT T-12)
DEEP BLUE FLUORESCENT
WAVELENGTH - ANGSTROMS

**Figure 9. Fluorescent lamps are now available in deep blue. The red component is filtered out by blue glass, allowing the lamp wide use in colored sign lighting.**

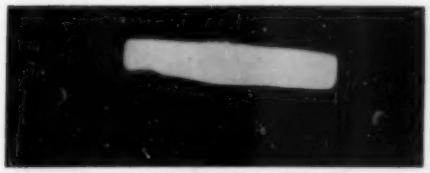


**Figure 11. A long felt need for wide sources of high intensity is filled by the horizontal carbon arc. Two small cathodes are visible, left and right, while the large rectangular area in the center is the end-on view of a rectangular carbon anode. The anode pictured here is about 1¼ inches wide.**

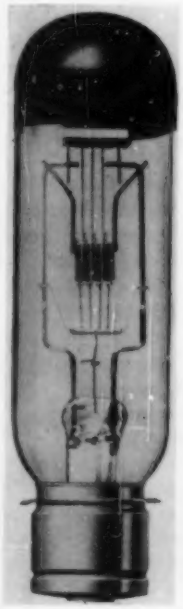


**Figure 12. (left) Screen brightness has increased 25 per cent by the use of the 1200-watt T12 projection lamp in 16mm movie projectors. This lamp is physically interchangeable with the 1000-watt T12.**

**Figure 8. Scintillating colored lighting effects resembling a spectacle of "colored fireflies" can now be created easily. A new "twinkle lamp" incorporates a small strip of bi'metal which causes the lamp to turn on and off independently on a low voltage multiple circuit. The repeating flashes of a "constellation" of the new lamps produce an interesting twinkling effect.**

**Figure 10. 150-watt PAR lamps are available in colors similar to the color range of the R40 line. Blue or pink tints are offered, with red, blue, green and yellow saturated colors. Translucent ceramic colors are fired on to resist weathering and fading.**

## Sources Have Changed

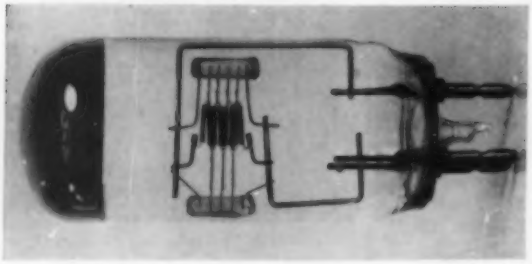


Figure 13. Low contour projectors are possible due to a projector lamp which operates "on its side," but with filament still vertical for high efficiency.

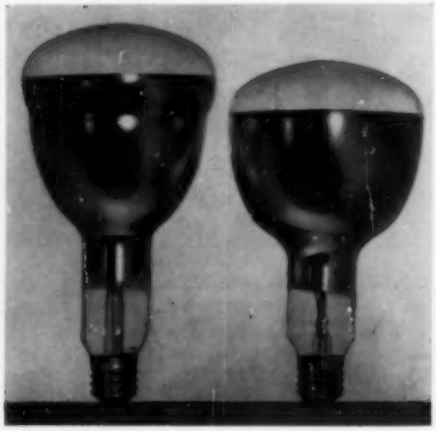


Figure 14. Industrial high mounting applications are served by a new 1000-watt RB52 lamp with a unique reflector contour allowing 1000-watt in the same diameter previously used for 500 or 750 watts. Price is said to be moderate, which perhaps depends on your point of view.

Figure 15. (left) A supplementary source is offered in a 30-watt R20 bulb. Small size and controlled distribution are its claims to fortune.

Figure 16. (right) Photoflash shooting distance has increased 30 per cent by pressure filling with oxygen. The M-2B, a blue bulb, color balanced for daylight film, is made possible by this pressure filling.

## Commercial and Industrial Equipment Has Changed

Figure 17. (right) Particularly in the relighting of older buildings there will be a use for a troffer incorporating air-conditioning. Connections from duct to troffer are made by flexible tubing.

## Commercial and Industrial Equipment Has Changed

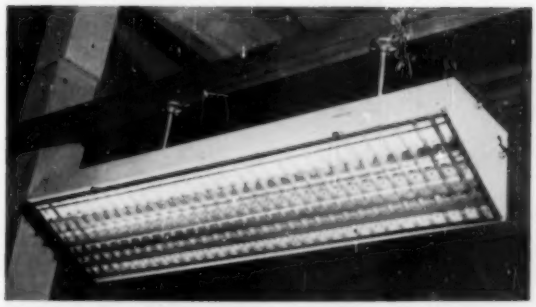


**Figure 18. Stock quotation boards, murals, etc., can be evenly illuminated from top to bottom by new wall lighting unit which allows individual adjustment of each louver and of each reflector. Reflectors are Alzak.**

**Figure 19. An experimental luminaire for high-current lamps has reduced longitudinal brightness by giving a triangular cross-section to each louver.**

**Figure 20. (left) Members of the barrel inspection industry will welcome a bung-up model of an explosion-proof portable. Next year we will report on progress in growing eyeballs on stalks with which to see what this unit has illuminated.**

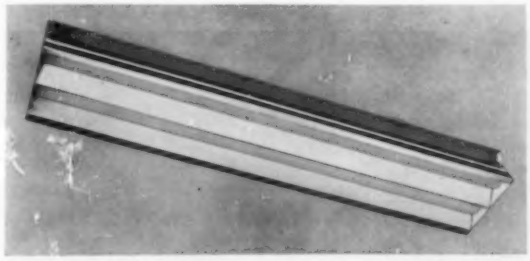


**Figure 21. Plastic shields have been added to T17 lamps to gain especially low brightness in a troffer unit.**

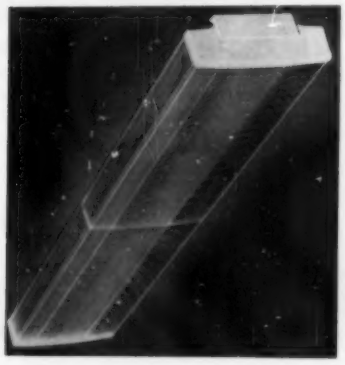


**Figure 22. (left) An acrylic plastic enclosure, made up of hundreds of tiny individual conical lenses, gives a widespread distribution pattern but keeps glare zone brightness under strict control.**

**Figure 23. An explosion-proof hand lamp has been designed for use with a 150-watt PAR in Class I Group D locations.**

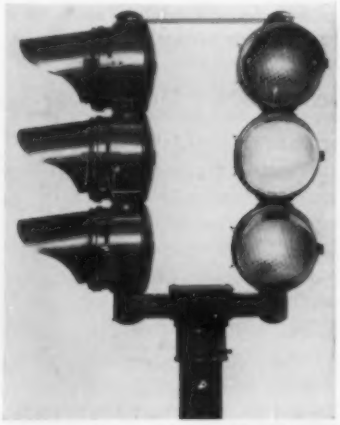
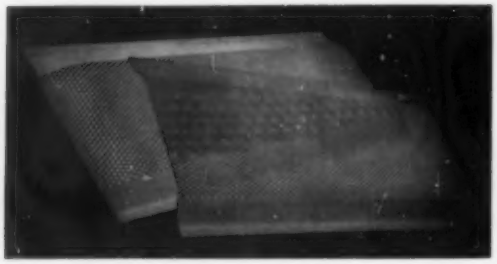


**Figure 24. An aluminum reflector for traffic signals replaces the glass reflector. False signal indication due to "sun phantom" is eliminated. Desired beam spread is gained by forming the reflector in four parabaloidal surfaces.**

## Luminaire Components Have Changed



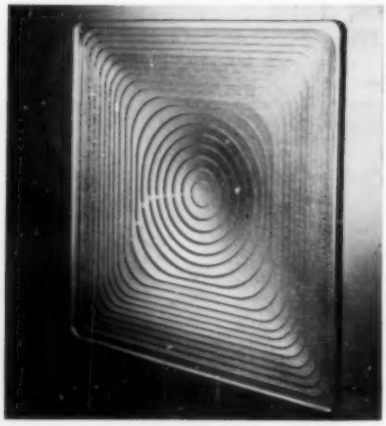


**Figure 25. Lens bottoms for luminaires have progressed from flat through curved lenses extending below the luminaire until today we have concave lenses, curving up into the luminaire. Lower lens brightness results.**

**Figure 26. Plastic extrusions are available with transverse patterns as well as longitudinal markings.**

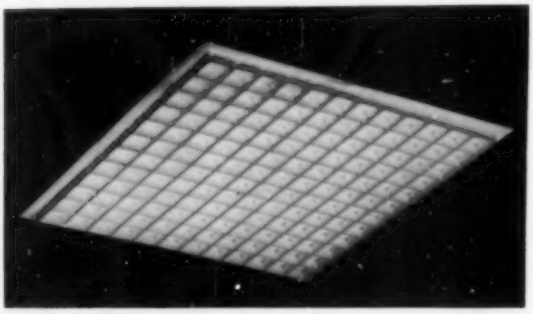


**Figure 27. Plastic louvers, for low direct glare, are fused together with a plastic diffusing panel for low reflected glare. The resulting unit is rigid and easily handled.**

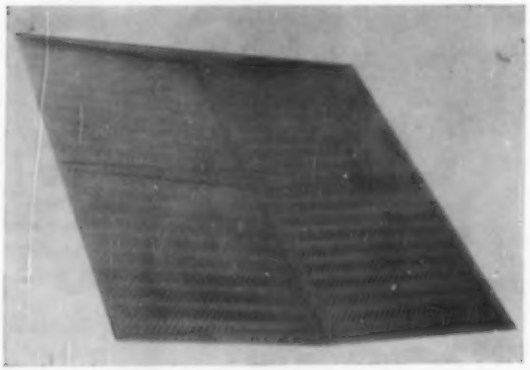


**Figure 28. Two-foot by two-foot acrylic panel incorporates tiny lenses to give low brightness. The panel is supported by ribs on one-foot centers, and is used either in the luminaires or in luminous ceilings.**

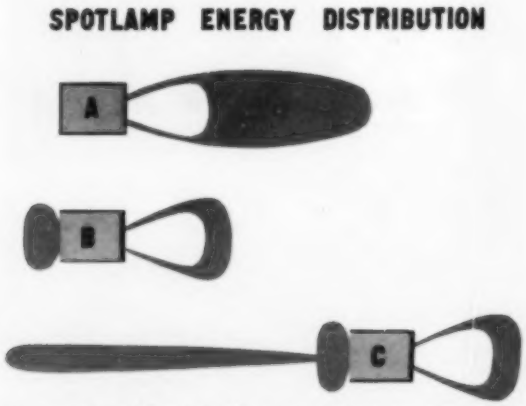



**Figure 29. A diebroic filter separates light from heat. (Shaded area is heat, light area is light.) The light or heat component can be transmitted or reflected (for lenses or reflectors). Movie and TV studios should be interested in this method of reducing heat on stage.**

# Daylighting Materials Have Changed

**Figure 30. Plate glass, so standard for years, has now taken unto itself a range of color. Color has similarly invaded glass block, which is now used for entire walls rather than simply as panels in a building.**

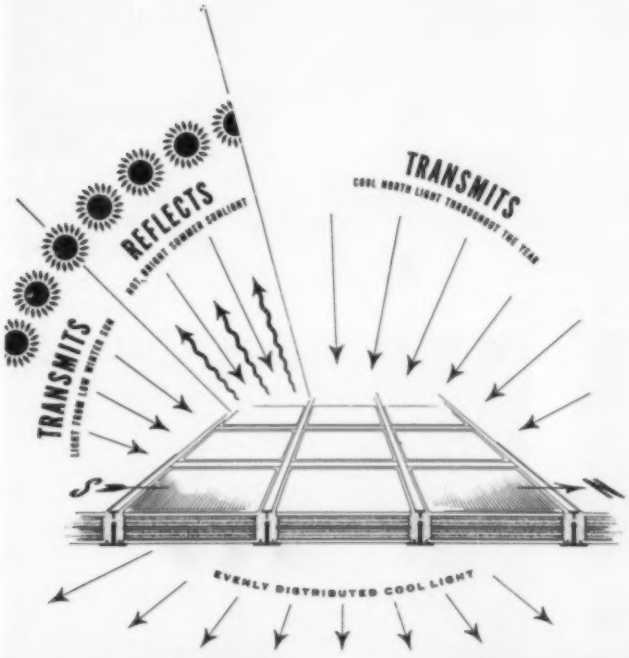
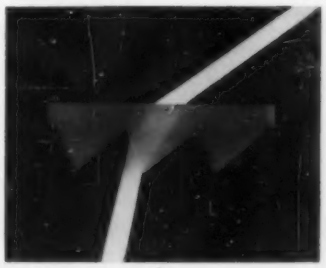



**Figure 31. Prismatic rejection is used in a glass block to reduce brightness in building interiors while using daylight as a major source of light. The diagram (left) illustrates this principle. In the three photos (a) shows light from a north sky passing through a prism on a horizontal skylight; (b) shows light from a low angle sun position in the south; (c) shows light from the high sun altitude angle such as exists in spring and summer. In this case the majority of the light is internally reflected back to the exterior so that the glare and solar heat, which become a problem with skylights during this time of year, are greatly reduced.**

a



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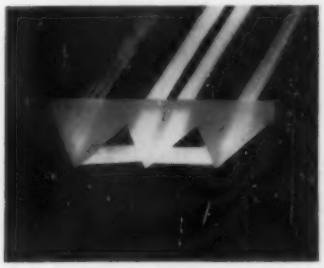


c

## Applications Are More Varied

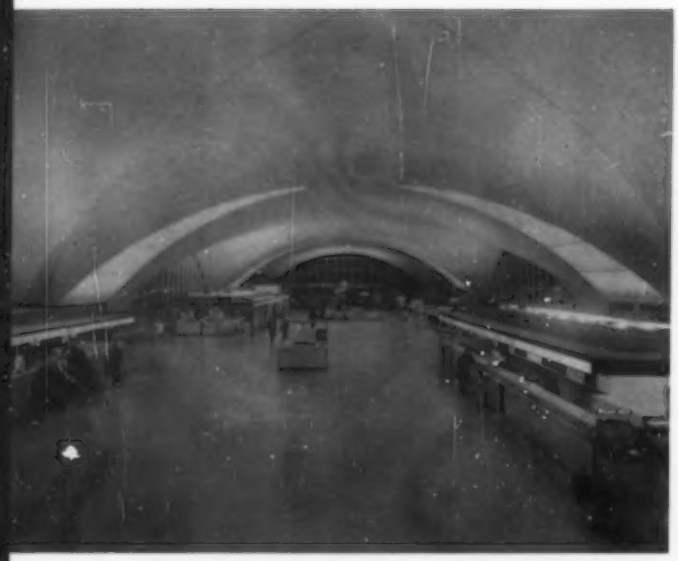


Figure 32. St. Louis airport terminal uses 110 1000-watt color improved mercury vapor lamps, neatly concealed on the tops of the concession kiosks. Ease of maintenance is apparent. The sky lights have glass tops and plastic bottoms; they contain slimline strips which contribute interior light and create a striking exterior pattern at night. Illumination reaches 50 to 75 footcandles.

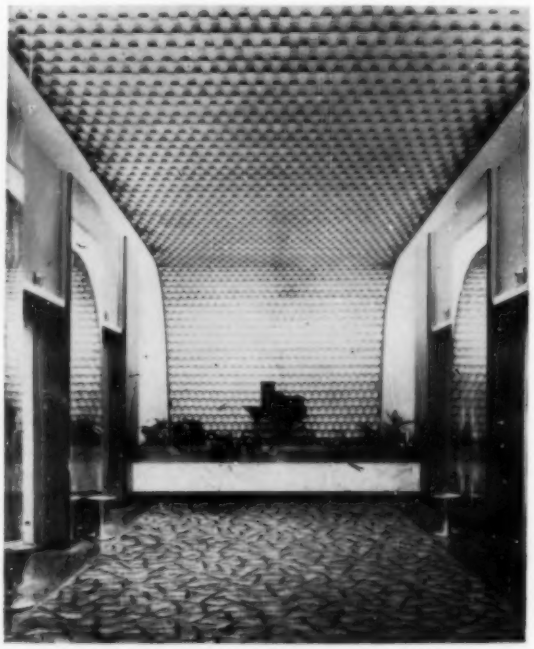


Figure 33. Dozens of two-inch wide strips of translucent plastic are woven on brass rods for the ceiling of the elevator lobby in the Dallas Statler-Hilton Hotel. It is lighted from above.

Figure 34. In the same hotel the desk is lighted to 40 footcandles by a plastic ceiling in gay colors.

Figure 35. Lighting from beneath the bannisters helps get you safely from here to there.

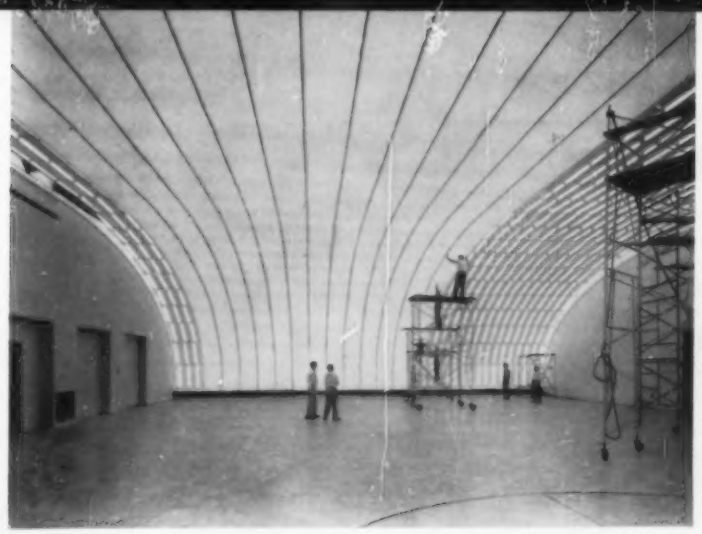


Figure 36. A luminous element covering the entire ceiling and a side wall in one smooth curved surface, is used at the Chrysler style stage. Strip lights are used behind the diffusing plastic.

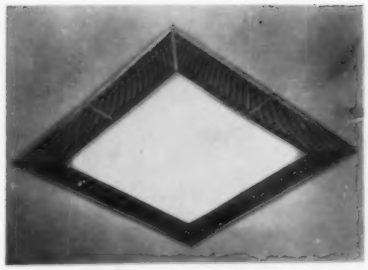


Figure 37. Grand Foyer of the New York Coliseum uses luminaires designed for 14 four-foot 800-ma lamps. General distribution is obtained through plastic panel; and an 18-inch Fresnel lens in the center of each panel gives downlight from a 500-watt incandescent lamp. Continuous air grilles are provided around luminaire.

Figure 38. Military Personnel Record Center in St. Louis—built to house 21 million armed service personnel records—is second in assignable space only to the Pentagon. Lighting is primarily for vertical surfaces. Flexibility is incorporated to permit shifting reflectors to suit aisle centers.

Figure 39. The first international exhibition of an American self-service market was made in connection with the meetings of the International Congress of Food Distribution and International Association of Food Chains in Rome, June 1956. The full size exhibition is complete from soup to nuts. Lighting is by single rows of louvered luminaires mounted between ceiling beams.

Figure 40. Relative size of the man standing at the center of the Congress Hall in the Esposizione Universale Rome indicates the size of the lighting equipment. Average illumination of 30 footcandles is provided by 480 48T12 slimline lamps.

Figure 41. Covered tennis court in Brussels, Belgium, may be lighted by both daylight and artificial lighting system. Lamps are mounted in polished aluminum reflectors between layers of double glazed skylight. Average illumination is 40 footcandles. There are 120 units over center court, 69 divided over the other two.

Figure 42. The first building to be completely lighted by fluorescent lamps has been relighted with new luminaires. The first generation has gone the way of all fixtures.

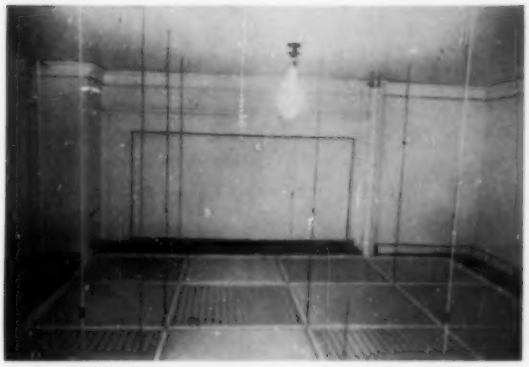


Figure 43. (left) Another interesting office installation cut the ceiling height by a luminous ceiling, lighted by a single 1000-watt color-improved mercury lamp mounted 6½ feet above the plastic panels.

Figure 44. (right) Before going ahead on a new building, the Connecticut General Life Insurance Co. built a full-scale test building in which they tried four or five types of lighting. Three basic lighting systems were tried: luminous ceiling, troffers and baffled system with low-current operation of 72T12 slimline lamps. Fenestration, flooring, partitions, furniture and equipment were also tested in the mock-up.

Figure 45. 500 footcandles have been installed in an office for regular office work. We will no doubt hear more about this installation next year.

Figure 46. At General Motors an art studio has a sloped plastic ceiling to help in utilizing daylight from the window-wall, and to give a more level illumination when the ceiling is lighted.

Figure 47. An office has been lighted to 250 footcandles with lamps behind two-foot by two-foot acrylic panels. Each panel incorporates small lenses to reduce brightness at high angles.

Figure 48. The movie projectionist now has his table equipped with a torchiere on dimmer control, so his audience can see to knit while he splices the broken reel of Aunt Lucy and the twins at Minnetonka.

**Figure 49. An industrial area in the electronics business has been lighted to 450 footcandles. It has been reported that the sharp reduction in rejections quickly paid for the installation.**

**Figure 50. Fluorescent lighting in a 30-foot high factory installation brings the illumination up to 50 footcandles.**

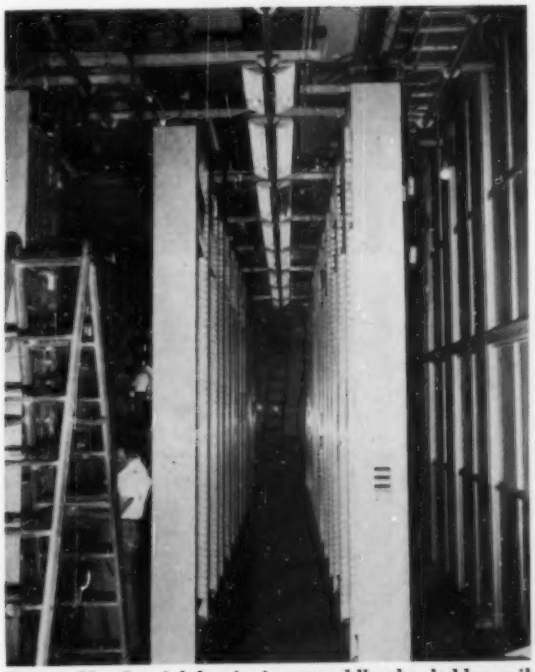


**Figure 51. Special luminaires straddle the ladder rail between frames of telephone equipment. They feature a telescopic feed to simplify installation at various spacings.**

**Figure 52. (below) Typical installation of the new 5¾-inch Dual Headlighting System. Mounting may be in various positions from horizontal, as shown, to vertical, one above the other. These new lamps, of increased wattage, with main driving beam filaments and passing beam filaments positioned on focus, provide greater illumination and increased distance visibility on the passing beam in either clear or inclement weather. The lamps are specially designed and fitted with aimer buttons to provide for mechanical aiming.**

Figure 53. The Chief Joseph Dam in Washington has outdoor illumination for working, for security, and for a tourist display. The major portion of this lighting is provided by 114 20,000-lumen mercury vapor lamps.

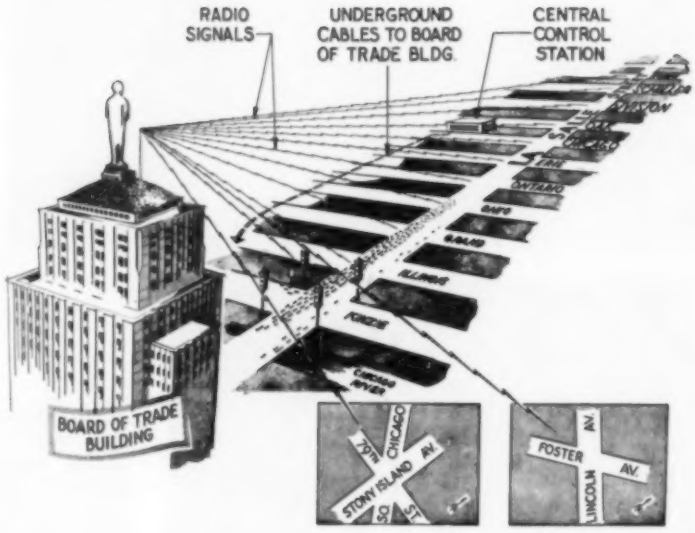
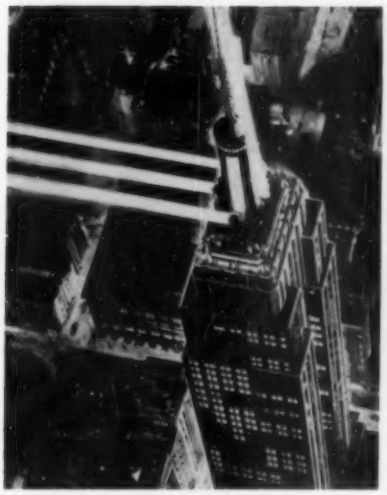



Figure 54. From the top of the Chicago Board of Trade Building FM radio signals select and supervise a traffic control program at each intersection in the system.

Figure 55. Golf has gone on a day and night schedule with a complete course illuminated to five footcandles on the Arroyo Seco in Los Angeles.

**Figure 56. The House of Parliament in Ottawa, Ont., is efficiently lighted in patriotic colors by properly selected gaseous discharge lamps.**

**Figure 57. Color filters are used on the units shown on the pole, directed at the facade of Rich's Department Store, Atlanta, Ga., here shown at night.**



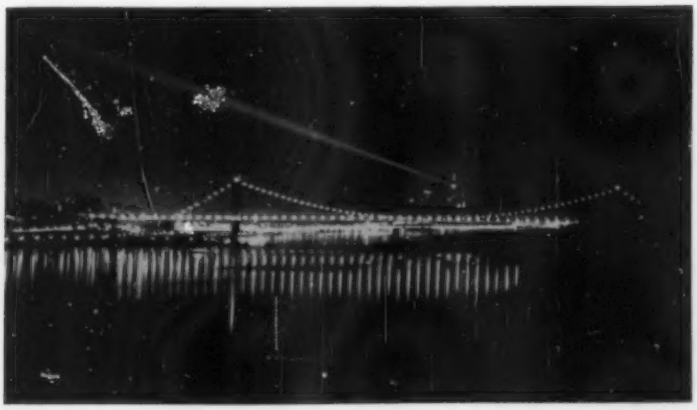


**Figure 58. The mercury vapor installation atop the Empire State Building incorporates motion to produce a "ballet." The searchlights revolve through horizontal, then vertical arcs, and are visible from miles away.**

Figure 59. An American castle in Disneyland is whimsical, even at night, with colored floodlighting.

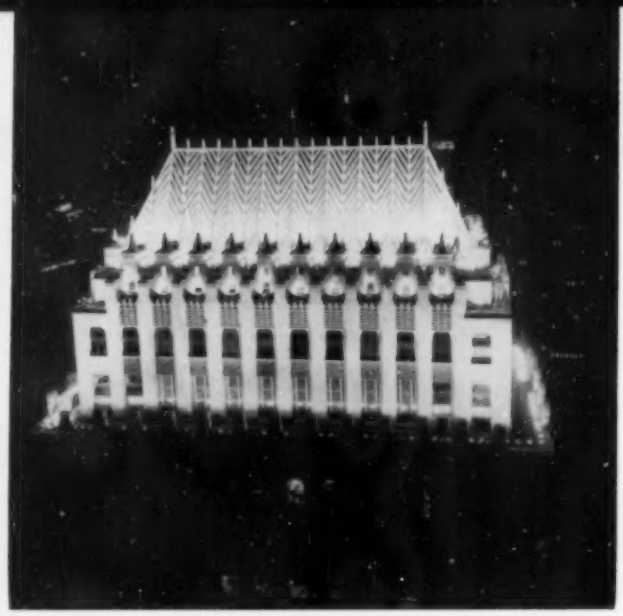


Figure 60. The Koppers Building in Pittsburgh uses mercury floodlights on the sloping roof and incandescent units on the vertical facades of the top three floors. This 87-kw job was turned on in July 1956.

Figure 61. The fountain at the Greater Pittsburgh Airport squirts 1400 gallons of water per minute into a cluster of pools 425 feet long. The connected lighting load is 56 kw.

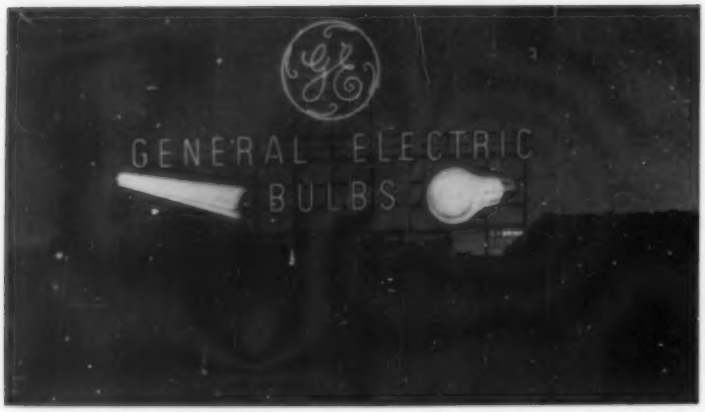



Figure 62. Reflector lamps, used in an outdoor sign in Boston, give visibility in daylight as well as at night.

Figure 63. Neon tubing has been "sculptured" into abstract art forms, beautiful in their own right without specific application.

Figure 64. 200 fluorescent units give an average of one footcandle to the Richmond-San Rafael Bridge near San Francisco. Mounting heights vary from 27 to 29 feet and spacing varies from 138 to 150 feet, staggered.

Figure 65. The Tappan Zee Bridge, from Nyack to Tarrytown, over the Hudson River, is spectacular with 258 400-watt mercury units.

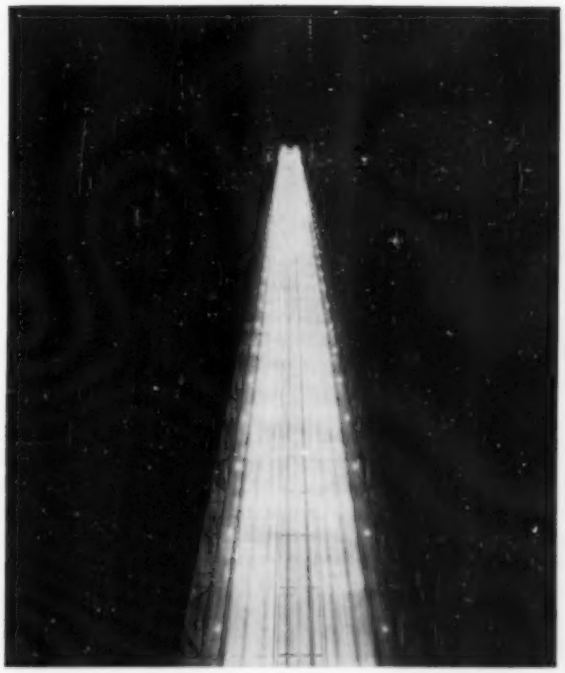


Figure 66. 222 mercury units are used on the 4760-foot George Washington Bridge in a recent relighting program by the Port of New York Authority.

Figure 67. A No. 1 photoflood lamp provides excellent illumination when used in a portable underwater floodlight. The unit can be used under 100 feet of water.

Figure 68. A fluorescent luminaire has been specifically designed for low temperature work where protected from weather.

Figure 69. Weatherproof fluorescent luminaires are now available for poster panels, floodlighting, etc., for use in conjunction with remote weatherproof ballasts.

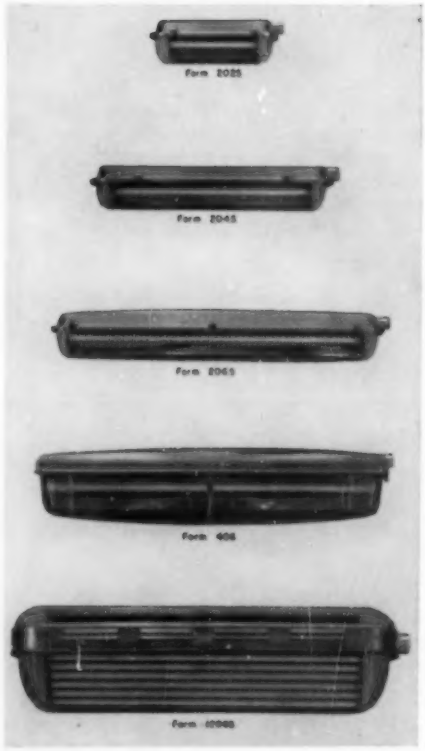



Figure 70. The fluorescent street lighting family includes a two-foot two-lamp baby and a six-foot twelve-lamp grandfather.

Figure 71. Color-improved mercury lamps up to 700-watt are usable in a new street lighting luminaire designed for the purpose.

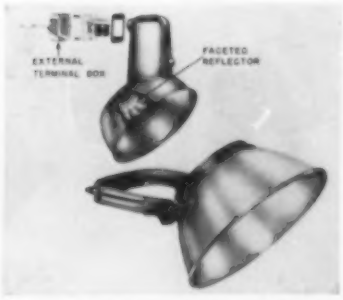



Figure 72. An external terminal box on an outdoor floodlight is intended to keep insulation temperatures down, thus promoting long life.

Figure 73. A broad sheet of light is produced with good efficiency by a bat-wing reflector, even with the color-improved mercury lamp. Available for 400-watt to 1000-watt.

# Residence Lighting Has Changed

**Figure 74. The ceiling luminaires you install in your apartment can be taken along when you move to Oshkosh, if they are designed to plug into the baseboard. Height can be adjusted, too.**

**Figure 75. A transilluminated wall keeps the Lares and Penates out of trouble, while a luminous ceiling on dimmer adjusts to your mood.**

**Figure 76. The lighting was up-dated in this remodelling job with two wall lamps, three center ceiling luminaires and a pulley unit over the dining table.**

Figure 77. A Cleveland remodelling demonstration utilizes a cornice, portables for reading, and an indirect spot over the dining table. Three pierced cones light the hall, and the kitchen has a luminous ceiling.

Figure 78. A desk lamp with a new shape is said to give more nearly even illumination on the work. An acrylic plastic shade redirects the light of a 150-watt silvered-bowl lamp to deliver high levels of illumination over normal desk work area.

Figure 79. A luminous element in a kitchen ceiling can be louvered by false beams. Fluorescent lamps above and below wall cabinets dispel gloom.

Figure 80. The hand-hewn beams still show in a remodelled Colonial home. Visible luminaires have been renewed and a cornice added.

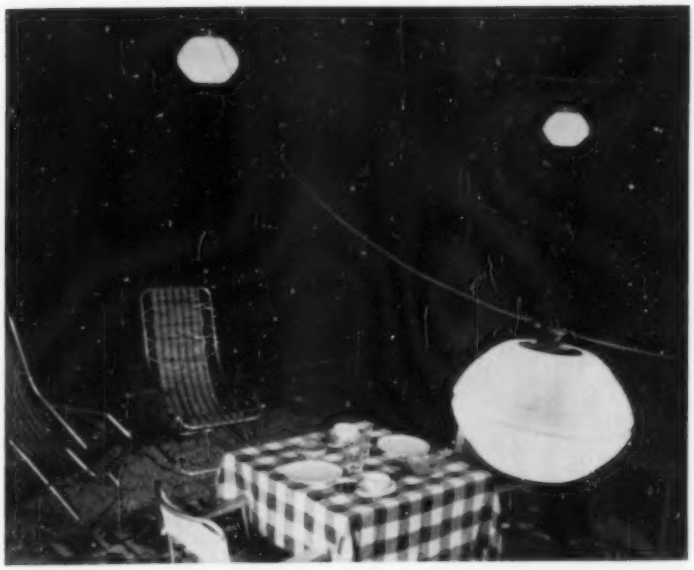


Figure 81. One-piece plastic bubbles in various colors, strung through the garden on molded connecting wires, are vastly more protected than Japanese lanterns, but the effect is every bit as gay.

Figure 82. Household-size lamps in several tints and colors are now available for bringing out subtle differences in home atmosphere. Tones range from cool to warm.

Figure 83. Miss Massachusetts (Miss Jewel Smerage of Boston) and Mr. Max K. Strang were interested in a new combination sombrero-type luminaire of light-weight plastic for residence lighting.

## Measurement Techniques Improve

**Figure 84. Photometry of street lighting luminaires *in place* is now possible with an easily portable box which is used to cover the luminaire *on the pole* (right) and measure its light output.**

## And other developments this year . . .

- The 400-watt mercury group now encompasses more color; developed this year were silver white, and gold mercury lamps (both 400-watt).
- Photofloods have been increased in power by a 300-watt R20 lamp. This new lamp can be used only on intermittent service to allow for cooling.
- Recognizing the lamp industry's current offerings, it may be of interest to know that 910 lamps were *delisted!*
- Ballasts are now available in weatherproof housings which are connected to light-weight remote luminaires by conduit. Cool operation results, together with slimmer luminaires.
- Plastic tops have been used on vans to allow truck men to see inside the body during the day.
- The I.E.S. Committee on Education has announced a need, during the next five years, for 3000 persons technically trained in lighting.
- The American Standards Association has embarked on a program of standardization among various manufacturers of grid suspensions, sprinklers, anemostats, recessed luminaires and ceiling material.
- An Italian book, "ESEMPI," contains hundreds of pictures of international lighting work, with convenient English subtitles.

An experimental study of the variation in the ratios between room surface brightnesses and working plane illumination — for a series of model room sizes with luminous ceilings.

Results of this study, designed as a check on the tables of calculation of illumination by the interflection method, were presented at the 1951 National Technical Conference of I.E.S. and published in preprint only. This was the first such study and since its presentation it has served as reference for numerous subsequent papers by others. For convenience as a further reference, the paper is here presented, in the same issue with additional studies on the subject by Bull, Wiseman and Spencer.

# Verification of the Interflection Tables

By RUSSELL D. CHURCHILL
RUSSELL C. PUTNAM

ILLUMINATING ENGINEERS have come, over the years, to the realization that satisfactory and comfortable lighting requires control of brightness distribution throughout the visual field. Extensive researches have been conducted concerning the effect of various brightness ratios in the visual field on visual function and comfort. The Illuminating Engineering Society through its Committee on Standards of Quality and Quantity for Interior Illumination has established various recommended brightness ratios to attain favorable seeing conditions.[1] Through technical committees of the Illuminating Engineering Society these recommendations have been expanded and applied specifically to the fields of office and school lighting.[2,3]

Lighting design should, therefore, include computation of these various brightness ratios as well as lighting levels if it is to predetermine completely the performance of a lighting installation. The contribution of interflections to these values, always an important factor, becomes increasingly so with the high reflectance surfaces now in common use.

Interflection of light within finite cylinders has been the subject of study for many years. The original work by Buckley, Yamauti, and Hisano led to the more recent studies by Moon and Spencer[4,5,6] which culminated in the establishment of tables from which surface brightnesses within rooms can be computed.[7,8,9]

The interflection theory has been applied to light wells and a very close agreement was found between theoretical calculations and experimental measurements.[10,11] No similar experimental verification of the interflection theory as applied to room brightnesses has been published. The practical importance and potentialities of the interflection method of predetermining room brightnesses and lighting levels are so significant that experimental verification of the theoretically determined tables is desirable. Such experimental verification, within the limits of the procedure employed, was made last year for rooms lighted by a luminous ceiling of uniform brightness.[12] In the past few months the procedure has been refined and the methods of measurement improved so that a more precise check became feasible, as reported in this paper.

## Experimental Room

The investigation was carried out using a model room with maximum internal dimensions of six feet in all directions. The room ratio value varied over a range of 0.167 to 1.000. This variation was obtained by moving the floor in six steps, thus altering the room height while the floor area remained constant. The room ratio (domance) as used in the

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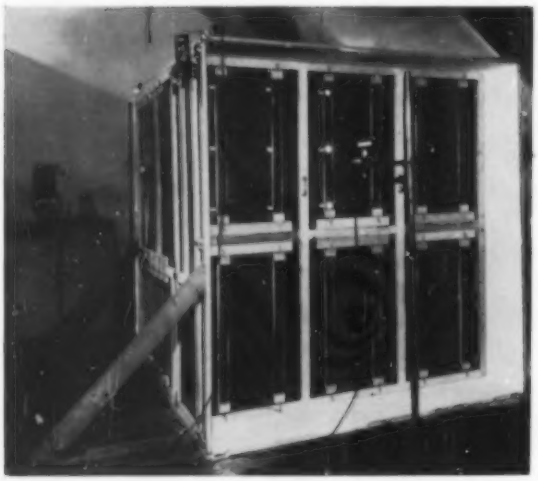
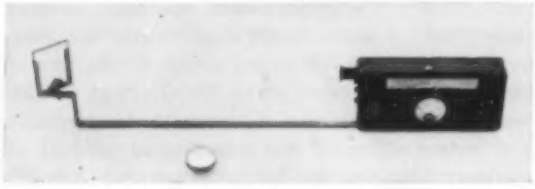


**Figure 1. Exterior view of the experimental room with the floor in position for a room ratio of 0.833. The Brightness Meter is placed to read the ceiling brightness through one of the apertures.**

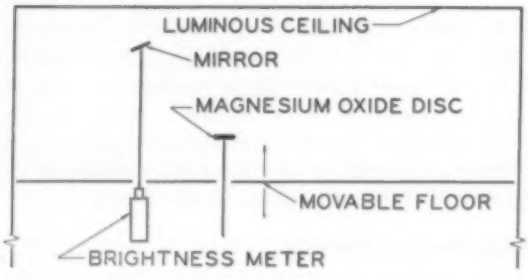
interflection tables is defined as:

$$k_r = \frac{h\,(l+w)}{2lw}$$

where $h$ is the height, $l$ the length, and $w$ the width of the room. For square rooms $k_r = \frac{h}{l}$.



(a)




(b)

**Figure 3. (a) Brightness Meter, mirror attachment, and magnesium oxide disk. The mirror may be positioned at any desired angle. (b) Sketch of the method used in rooms of low room ratio to measure working plane illumination and floor brightness. The mirror position depends upon the location of the area being measured.**

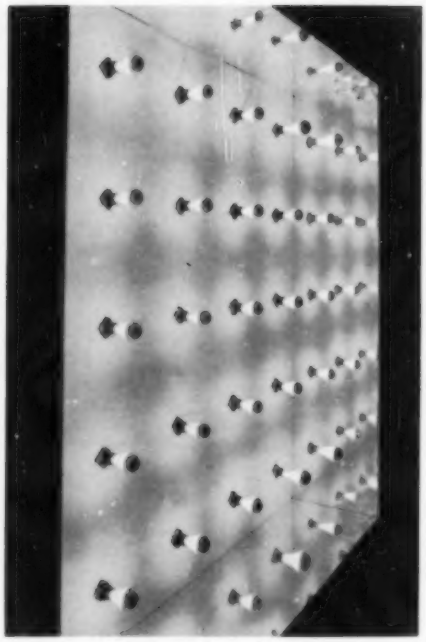


**Figure 2. View of the ceiling cavity showing the position of the silvered-bowl lamps, diffuse reflecting surface, and polished aluminum sides. Note the apparent extension of the cavity due to the polished sides.**

Actual positioning of the experimental room is such that the ceiling and floor are in vertical planes to facilitate movement of the floor and the taking of measurements. Fig. 1 shows an exterior view of the experimental room with the floor in position for a room ratio of 0.833. Illumination and brightness readings are recorded from outside the room through the removable sections seen in the floor. In Fig. 1 one solid section has been removed and replaced with another containing three apertures through which readings are taken. Similar removable sections are located in one wall.

Wall and floor surfaces are formed of masonite and painted with integrating sphere paint to approach perfectly diffusing surfaces as closely as possible. The floor reflectance was reduced by the addition of lampblack paste to the sphere paint. Reflectance values obtained were 85 per cent for the wall and 27 per cent for the floor.

### Ceiling and Lamp Cavity

A luminous ceiling was used as a light source since its brightness can be controlled very closely, it has direct practical application in lighting design, and theoretical interflection equations and tables have been published for this type of lighting.[5,6] The ceiling was formed of tracing paper and illu-

**TABLE I — Experimental and Theoretical Ratios of Brightness and Illumination.**

| Room Ratio | | 0.167 | 0.333 | 0.500 | 0.667 | 0.833 | 1.000 |
|---|---|---|---|---|---|---|---|
| $B_2/B_{02}$ | Experimental Value | 1.27 | 1.31 | 1.32 | 1.34 | 1.36 | 1.38 |
| | Theoretical Value | 1.25 | 1.29 | 1.31 | 1.33 | 1.35 | 1.36 |
| $B_2/E_{AV}$ | Experimental Value | 1.13 | 1.27 | 1.41 | 1.57 | 1.70 | 1.87 |
| | Theoretical Value | 1.12 | 1.25 | 1.38 | 1.53 | 1.69 | 1.86 |
| $B_{1M}/E_{AV}$ | Experimental Value | 0.563 | 0.605 | 0.639 | 0.670 | 0.691 | 0.707 |
| | Theoretical Value | 0.570 | 0.600 | 0.630 | 0.658 | 0.688 | 0.718 |
| $B_{1T}/E_{AV}$ | Experimental Value | 0.611 | 0.662 | 0.723 | 0.792 | 0.840 | 0.887 |
| | Theoretical Value | 0.597 | 0.653 | 0.714 | 0.772 | 0.835 | 0.899 |
| $B_3/E_{AV}$ | Experimental Value | 0.257 | 0.254 | 0.242 | 0.233 | 0.228 | 0.219 |
| | Theoretical Value | 0.260 | 0.250 | 0.241 | 0.232 | 0.224 | 0.216 |
| $E_{AV}/B_{02}$ | Experimental Value | 1.13 | 1.03 | 0.941 | 0.852 | 0.798 | 0.739 |
| | Theoretical Value | 1.12 | 1.03 | 0.949 | 0.872 | 0.796 | 0.730 |

minated from a cavity utilizing silvered-bowl incandescent lamps. The ceiling reflectance, including the effect of the cavity, was 65 per cent. All reflectance values were measured under diffuse illumination with a Luckiesh-Taylor Brightness Meter and a magnesium oxide reflectance standard. The values were then checked with a Baumgartner Reflectometer.

A symmetrical lighting pattern was obtained throughout the room. With such a pattern the brightness of only one wall and illumination values and floor brightnesses of only one quadrant need be investigated. Symmetry was insured by photometering the lamps in an integrating sphere and arranging them in the cavity in a symmetrical pattern according to light output. Light distribution symmetry was verified for two room sizes.

The ceiling cavity, shown in Fig. 2, has the same

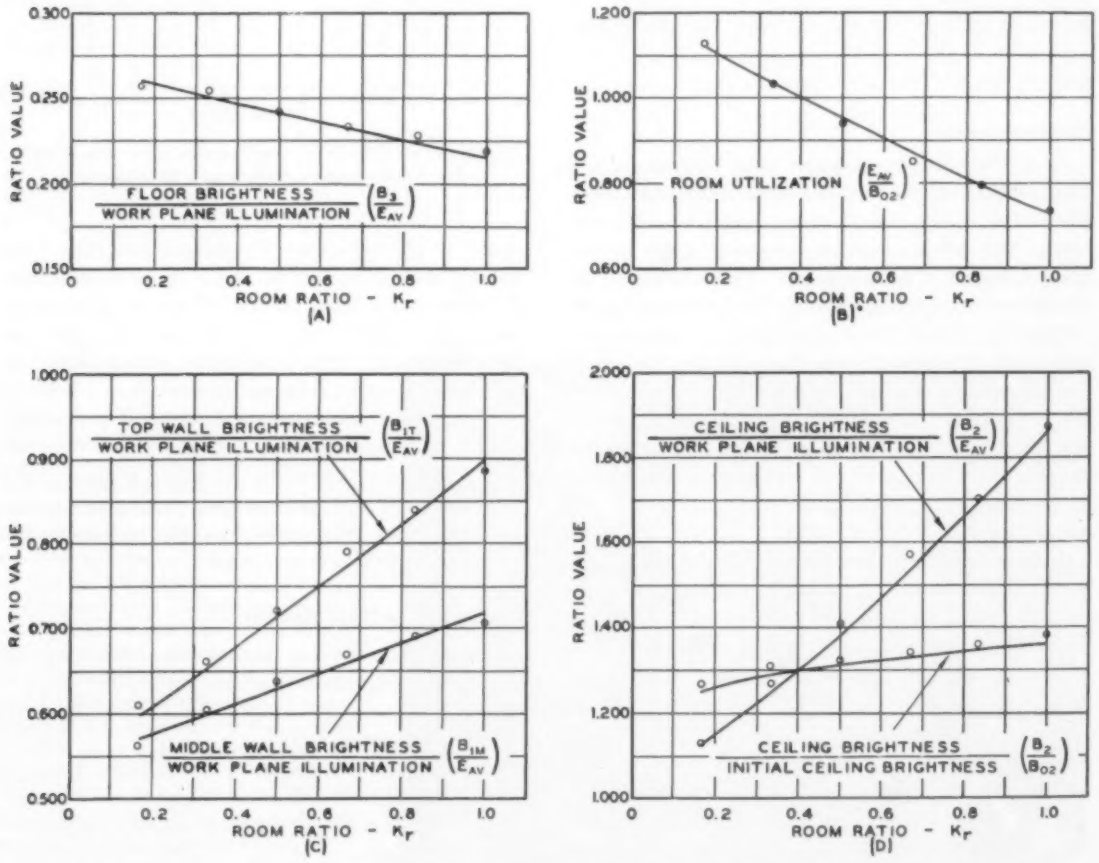

RATIO VALUE
FLOOR BRIGHTNESS / WORK PLANE ILLUMINATION (B3/EAV)
ROOM RATIO - Kr
(A)
ROOM UTILIZATION (EAV/B02)
ROOM RATIO - Kr
(B)
TOP WALL BRIGHTNESS / WORK PLANE ILLUMINATION (B1T/EAV)
MIDDLE WALL BRIGHTNESS / WORK PLANE ILLUMINATION (B1M/EAV)
ROOM RATIO - Kr
(C)
CEILING BRIGHTNESS / WORK PLANE ILLUMINATION (B2/EAV)
CEILING BRIGHTNESS / INITIAL CEILING BRIGHTNESS (B2/B02)
ROOM RATIO - Kr
(D)

**Figure 4. Comparison of theoretical curves and experimental values for various interflectance ratios. The solid lines are the computed theoretical values; the individual points are values obtained experimentally.**

area with a depth of 16 inches. The back is a high reflectance asbestos board and the sides are polished aluminum sheet. The aluminum sheet gives the cavity an almost infinite appearance and helps to build up the ceiling brightness near the edges. Silvered-bowl lamps on 14½-inch centers are used to prevent direct light from reaching the tracing paper. The depth-to-spacing ratio of 0.33 is such to give satisfactory brightness distribution on the back of the cavity. 100-watt lamps are used in the corner with 60-watt lamps in other positions.

The maximum variation of ceiling brightness, including the extreme corners, was only 3 per cent from the average value. To secure such brightness uniformity voltage was adjusted to various groups of the lamps by means of variacs. Line voltage was regulated with a manually-controlled 1.65 kva regulator. All lamps were seasoned and operated at a voltage under the rated value during the test period. A second observer maintained constant lamp voltage throughout the tests. A contact-making ammeter and electronic relay were employed to indicate the failure of any lamp during the test period. No failures occurred during the tests. The degree of ceiling diffusion was such that the brightness at an angle of 85 degrees from the normal was only 12 per cent below the normal value.

### Measurements

It is desirable to measure both brightness and illumination values with the same instrument since the ratios under consideration involve both variables. The effect of errors inherent in the instrument would thus be minimized. For this reason all measurements were made with the Luckiesh-Taylor Brightness Meter. Ceiling brightness values were measured through the apertures in the floor and wall brightness values on one wall were measured through the apertures in the opposite wall. Illumination values at the working plane height (¼ room height) were obtained by placing a magnesium oxide disk within the room at the proper height and measuring the disk brightness.

For the larger rooms both floor brightness and working plane illumination were measured directly through the apertures in the wall. This was not possible with the smaller rooms because of the low angles at which readings would have been taken. It was, therefore, necessary to use the Brightness Meter attachment shown in Fig. 3 (a). By means of the mirror it is possible to measure the brightness of an area on the floor or on any working plane parallel to the floor. Fig. 3 (b) illustrates the use of this attachment. The mirror was placed in the room through an open slot in the floor and adjusted so that the observer could see the area desired at an angle to give accurate brightness readings. The mirror was calibrated at the several angles used. Brightness and illumination values on all surfaces and planes were measured at one-foot intervals. The Brightness Meter calibration was periodically checked throughout the test period.

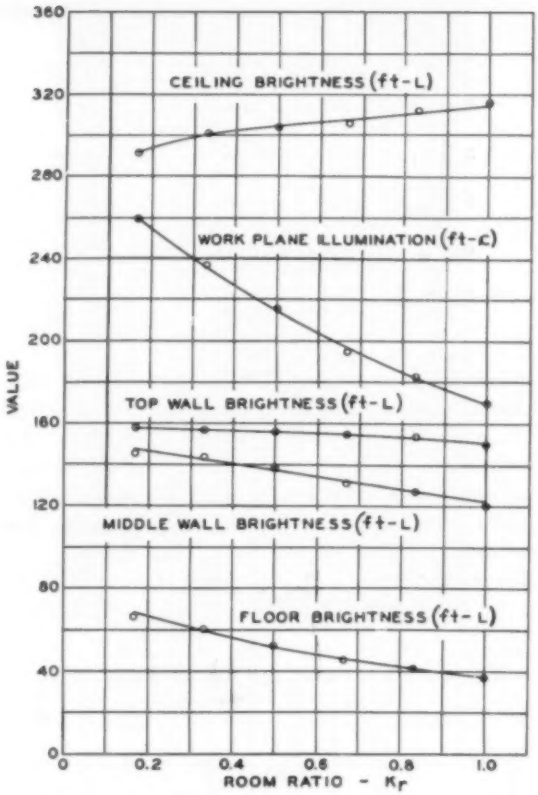



**Figure 5. Curves of the experimental values of brightness and working plane illumination.**

To measure initial ceiling brightness it was necessary to eliminate room interflections. This was accomplished by covering the entire ceiling with a panel painted with diffuse black paint and measuring the ceiling brightness through openings in this panel at appropriate positions.

### Summary of Test Results

The symbols used in summarizing the work are:

$E_{AV}$ = Working plane illumination at $h/4$*

$B_{1T}$ = Wall brightness at ¼ the distance from the ceiling to floor*

$B_{1M}$ = Wall brightness at ½ the distance from the ceiling to floor*

$B_{02}$ = Initial ceiling brightness — no room interflections

*As used in the interflection tables.[6, 7, 8, 9]

$B_2$ = Ceiling brightness
$B_3$ = Floor brightness

The experimental and theoretical values of the various interflection ratios are given in Table I. Fig. 4 presents these values graphically for the several room ratios. The theoretical values are based on equations published by Moon and Spencer for rooms lighted entirely from a luminous ceiling.[5] Experimental ratios were computed directly from meter readings employing the same meter filter throughout. Fig. 5 presents the average curves of the experimental values of surface brightnesses and working plane illumination.

An analysis of the experimental data shows a maximum difference of four per cent between the experimental and theoretical values of the various ratios. Most of the differences are of a considerably lower order.

This investigation shows a very close agreement between experimental and theoretical values of interflection ratios for specific conditions. This experimental verification of brightness ratios for rooms lighted by the ceiling gives assurance to the illuminating engineers of the validity of this method of lighting design. The accuracy of the practical application of the interflection method depends on the actual room conditions in much the same manner as does the accuracy of the conventional lumen method of lighting calculation.

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**A LEVEL OF 75 footcandles maintained is supplied directly on the shoe chairs, at O'Connor and Goldberg Shoe Store, in Chicago, by an incandescent installation. Two-foot-square recessed louvered reflector units, each with a 300-watt silvered bowl lamp, are arranged in groups of four spaced 15 feet on centers. These are augmented by 150-watt recessed spots.**

**Wall and cove illumination utilize 4-foot single-lamp fluorescent strips. The purse and hosiery area (at rear in photo) is lighted by 150-watt spots and 4-lamp recessed fluorescent units. Levels in this area are 100 footcandles on show cases and 125 footcandles on displays.**

**Installation designed by Walter H. Sobel and J. Stewart Stein, architects, engineers, consultants, of Chicago.**

# Interflections in a Room With Luminous Walls

By HEMPSTEAD S. BULL

One of the outstanding achievements of the past decade in the field of lighting theory was the development by Moon and Spencer of the interflection equations, and their subsequent demonstration of the proper use of these equations in the prediction of brightness and illumination ratios for rooms of various proportions. As the possibilities of this new approach became more widely appreciated it became apparent that some form of experimental vertification of the ratios derived from the interflection equations should be attempted.

With this in mind R. D. Churchill and R. C. Putnam set up a model room equipped with a luminous ceiling of uniform brightness, and determined certain significant brightness and illumination ratios for a wide range of ceiling heights. The results, reported at the 1951 I.E.S. National Technical Conference in Washington, showed close agreement between ratios determined from test data and the corresponding ratios calculated from the interflectance equations.

In 1953, R. S. Wiseman began a comprehensive experimental investigation of interflections, employing a model room six feet square with a movable floor to make it possible to change the room proportions easily. The walls and ceiling were composed of translucent Plexiglas backed up by high-reflectance cavities containing numerous incandescent lamps. Thus the walls and/or ceiling could be made, in effect, self-luminous in any desired combination of brightness patterns. Three types of situations were studied:

(a) a luminous ceiling of uniform brightness,
(b) four luminous walls of uniform brightness,
(c) a luminous floor.

The published results of this investigation[1] indicated fair agreement between experimentally determined brightness ratios and the corresponding ratios obtained from the interflectance equations. Small but consistent differences appeared which were larger than could be attributed to experimental error alone, and it was recommended that certain minor changes be made in the development of the theoretical equations.

The present paper presents the results of similar tests performed at the University of Michigan in 1953 quite independent of Dr. Wiseman's work but employing similar methods. This investigation was financed in large measure by the Illuminating Engineering Research Institute, and was confined to experimental studies of interflection in a model room equipped with four luminous walls.

### Model Room

A square room measuring three feet on a side was used. The ceiling height was adjustable, up to a maximum of three feet for a cubical room. The ceiling and floor were composed of plywood sheets, coated with flat paint to give the desired reflectances; the walls were formed of sheets of tracing vellum stretched over masonite boxes which served as luminous cavities.

Fig. 1 is a photograph of the model room as set up for the tests. Note that the room has been turned on its side for convenience. The vertical plywood panel is serving as the ceiling; a similar panel beyond and parallel to it serves as the floor. Some of the ¾-inch holes in the ceiling panel through which brightness readings were taken are plainly visible. Resting on the framework supporting the ceiling panel are two ¾-inch brass tubes. One has a metal cup attached which serves as a holder for a cylindrical block of magnesium oxide; the other has a brass housing containing a 45-degree mirror. The functions of these devices will be described later.

### Wall Cavity

Each of the four wall cavities was composed of a Masonite box three feet square and about 14 inches deep. It contained four fluorescent tubes (48-inch white) with the ends projecting through the side walls. They were spaced on 10¼-inch cen-

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHOR: Associate Professor of Electrical Engineering, University of Michigan. This study is sponsored by the Illuminating Engineering Research Institute as Project No. 4. Approved by the Research Executive Committee and by the Board of Trustees.

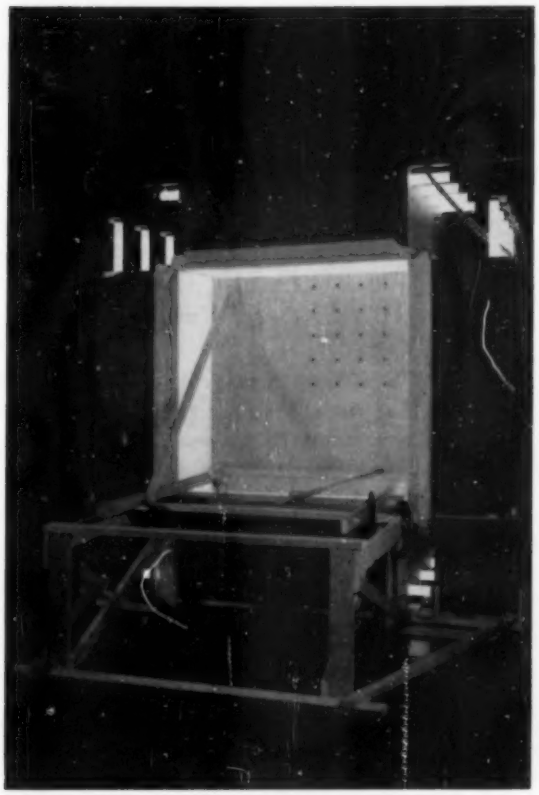

**Figure 1. View of Model Room Structure.**

ters about 12 inches behind the vellum which covered the cavity. The interior of the box was painted glossy white with a reflectance of about 80 per cent. The brightness of the outer surface of the vellum was very uniform, the ratio of maximum to minimum brightness being about 1.10.

### Instrumentation

A Luckiesh-Taylor brightness meter was employed for all readings. It was calibrated at 8 points on its scale by sighting at a magnesium oxide surface placed on a photometer bar and exposed to a reference lamp of known candlepower. The 10 and 100 filters of this instrument were calibrated in the same manner. Frequent check calibrations at one point on the scale were performed by the use of the portable brightness reference standard supplied with the instrument. This was done after every 30 to 45 minutes of use, and whenever erratic behavior was noted the comparison lamp bulb within the meter was replaced by a new one.

Footcandle readings at the desired distance above the floor of the model room were taken by sighting through a convenient aperture in the ceiling at a magnesium oxide test plate supported on a brass tube projecting through the proper floor aperture.

Floor and ceiling brightness readings were taken by sighting through appropriate apertures in the ceiling and floor. To obtain wall brightness readings a small 45-degree mirror was employed. This was supported at the end of a brass tube projecting through a floor aperture, and was viewed by the brightness meter sighting through the corresponding ceiling aperture. The reflectance of the mirror when used in this manner was found to be 90 per cent.

A voltage regulator for the fluorescent lamp supply circuit was not readily available. A close watch, however, was kept on the actual socket voltage and whenever it deviated appreciably from the desired value the brightness readings were adjusted in accord with the assumption that a one per cent change in voltage produced approximately a one per cent change in light output.

Axial symmetry being present in the model, floor and ceiling observation apertures were confined to one-fourth of the surfaces, as shown in Fig. 1. Twenty-five uniformly-spaced apertures were provided in the floor and ceiling panels.

### Room Reflectances

The ceiling was painted with three coats of white sphere paint and measured 84 per cent reflectance. The floor was painted with four coats of sphere paint darkened with lampblack and measured 15 per cent. These measurements were taken with a Baumgartner reflectometer. The vellum reflectance (backed up with black velvet) was 41 per cent and its transmittance was 46 per cent. The Masonite surfaces of the wall cavity had 80 per cent reflectance. The equivalent reflectance of the outer surface of the vellum including cavity interflection effects was computed by the use of the Moon-Spencer equation[2] and amounted to 58 per cent.

### Test Procedure

The ceiling and floor panels were placed in position with a three-foot separation to produce a cubical room. The fluorescent lamps were turned on and allowed to stabilize for ten minutes or so. All the floor apertures were plugged with corks painted to blend with the floor surface. All except one of the ceiling apertures were similarly plugged, and the brightness meter was sighted at the floor directly opposite this aperture. The cork in the adjacent ceiling opening was then removed and the floor brightness measured at the spot directly opposite this aperture. This procedure was repeated

until a total of 25 brightness readings of uniformly- spaced floor areas had been taken. A similar set of 25 brightness readings was taken of uniformly-spaced ceiling areas sighted through corresponding floor apertures.

The brass tube holding the magnesium oxide test plate was then inserted in one of the floor apertures and clamped in position with the test plate parallel to the floor and a distance from it equal to one-quarter the ceiling height, and a sight at the test plate was taken through the ceiling aperture directly opposite. The test plate holder was then transferred to an adjacent floor aperture and another reading taken through the corresponding ceiling aperture. This process was continued until a total of 25 readings at uniformly spaced stations had been taken. The reflectance of the magnesium oxide was assumed to be 97 per cent for the purpose of computing the footcandles received by it. The average of these 25 readings was considered to be the average workplane footcandles.

The test plate holder was then removed and the tube supporting the 45-degree mirror was put in its place. The distance from the mirror to the floor was made equal to half the ceiling height and it was placed successively at each of five stations forming a horizontal row, with the mirror facing upward so as to present the image of five spots uniformly spaced along the center line of the upper wall in the model (see Fig. 1). It was then placed successively at each of five stations forming a vertical row, with the mirror facing to the right (see Fig. 1) so as to present the image of five spots uniformly spaced along the center line of the right-hand wall. For each of these 10 positions the brightness meter was sighted at the mirror through the appropriate ceiling aperture and the average of these 10 readings was taken as the mid-wall brightness.

The distance from floor to ceiling was then reduced to 0.8 of the room width by moving the ceiling panel partially into the cavity formed by the four luminous walls. See Fig. 1. All of the readings described above were repeated so that average floor brightness, ceiling brightness, workplane footcandles and mid-wall brightness might be determined for this new room shape. Similar sets of readings were obtained for ceiling-to-floor spacings equivalent to 0.6, 0.4, and 0.2 of room width.

After surveying all the data and taking numerous repeat readings to reduce observational and instrumental errors to a minimum, one of the luminous wall boxes was removed and set up in the darkened laboratory. With its lamps operating just as they were when the box was part of the model room structure 25 brightness readings at approximately uniform spacing over one-quarter the luminous area of the vellum were taken, and the average was considered to be the reference brightness for the walls without interflections.

### Symbols

The symbols used in presenting the test data and the ratios derived therefrom are the same as were employed in S.Q.Q. Report 3 published in the IES Transactions.[3] They are redefined here for convenient reference.

$k_r$ = room coefficient, which is the ratio of ceiling height to room width for a square room.
$r_1$ = wall reflectance, in this case including interflection effects within the wall cavity.
$r_2$ = ceiling reflectance.
$r_3$ = floor reflectance.
$B_{1M}$ = average wall brightness midway between floor and ceiling.
$B_2$ = average ceiling brightness.
$B_3$ = average floor brightness.
$B_{o1}$ = average wall brightness without interflections.
$E_{av}$ = average illumination on a work plane one-quarter of the distance from floor to ceiling.

In this investigation all brightness values are in footlamberts and $E_{av}$ is in footcandles.

### Test Results

The reference brightness of the walls without interflections, $B_{o1}$, was determined from the 25-station average, corrected for scale and filter errors and voltage changes. Its value was 458 footlamberts.

Five values of $k_r$ were chosen: 1.0, 0.8, 0.6, 0.4, 0.2. Reflectances were: $r_1$, 0.58; $r_2$, 0.84; $r_3$, 0.15.

The ratios $B_{1M}/B_{o1}$, $B_2/B_{o1}$, $B_3/B_{o1}$ and $E_{av}/B_{o1}$ as determined from the experimental data are shown by the dashed lines in Figs. 2 and 3, and should be compared with the adjacent solid lines showing these same ratios computed from the interflection equations.[4] Referring to Fig. 2 it will be noted that the experimental curves fall well below the computed curves. In fact the differences are much larger than can reasonably be attributed to instrumental and observational errors. It is also evident that the experimental data seem to be more nearly a linear function of $k_r$, instead of an exponential function.

The data presented in Fig. 3 show the same trend. The observed values are less than the predicted values and are more nearly in linear relationship to $k_r$.

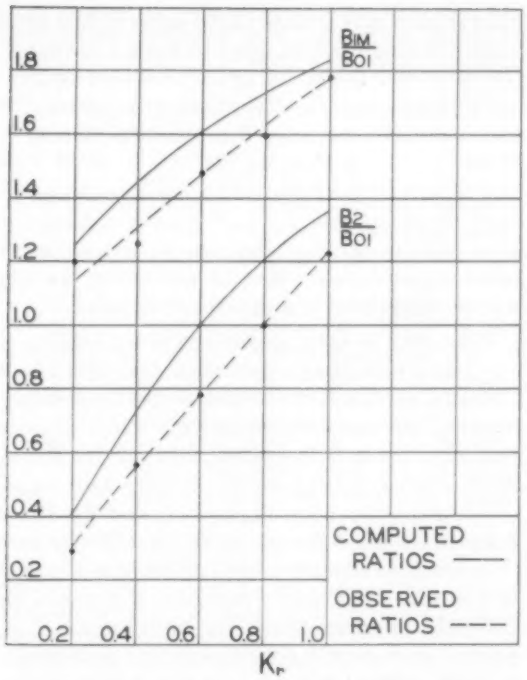


**Figure 2. The ratios $B_{1M}/B_{01}$ and $B_2/B_{01}$.**

As would be expected there is much closer agreement between theoretical and observed values in the ratios of $B_{1M}$, $B_2$ and $B_3$ to $E_{av}$ as shown in Fig. 4. An outstanding exception is the value of $B_3/E_{av}$ when $k_r$ is 0.2. It seems likely that the high observed value here is due to the departure of magnesium oxide from the cosine law. The interflection contribution to $E_{av}$ is very small for this room ratio and the direct light reaching the test plate from the luminous walls is confined to a zone extending up from the horizon about 10 degrees to 15 degrees. At this near-grazing angle a low reading for $E_{av}$ would be expected.

The experimental data and the corresponding computed values used in plotting the curves of Figs. 2, 3 and 4 are listed for ready reference in Table I.

## Conclusion

It is possible that the rather consistent discrepancy between the observed and predicted values may be due to:

(a) errors in the measured reflection factors,

(b) error in computing the equivalent reflectance of the luminous walls,

(c) errors in the application of the Moon-Spencer interflection equations to the particular constants pertaining to this model room,

**TABLE I.**

| $k_r \longrightarrow$ | 1.0 | 0.8 | 0.6 | 0.4 | 0.2 | |
|---|---|---|---|---|---|---|
| $B_{1M}/B_{01}$ | 1.83 | 1.73 | 1.61 | 1.45 | 1.25 | calculated |
| | 1.78 | 1.60 | 1.48 | 1.26 | 1.20 | observed |
| $B_2/B_{01}$ | 1.36 | 1.20 | 0.995 | 0.732 | 0.403 | calculated |
| | 1.23 | 0.99 | 0.785 | 0.565 | 0.300 | observed |
| $B_3/B_{01}$ | 0.254 | 0.237 | 0.210 | 0.168 | 0.102 | calculated |
| | 0.235 | 0.201 | 0.173 | 0.135 | 0.100 | observed |
| $E_{av}/B_{01}$ | 1.72 | 1.57 | 1.36 | 1.05 | 0.62 | calculated |
| | 1.57 | 1.30 | 1.07 | 0.82 | 0.47 | observed |
| $B_{1M}/E_{av}$ | 1.06 | 1.10 | 1.18 | 1.38 | 2.01 | calculated |
| | 1.13 | 1.23 | 1.38 | 1.54 | 2.53 | observed |
| $B_2/E_{av}$ | 0.792 | 0.765 | 0.732 | 0.697 | 0.650 | calculated |
| | 0.787 | 0.763 | 0.733 | 0.690 | 0.635 | observed |
| $B_3/E_{av}$ | 0.147 | 0.151 | 0.154 | 0.160 | 0.165 | calculated |
| | 0.150 | 0.154 | 0.161 | 0.165 | 0.210 | observed |

(d) errors in the Moon-Spencer equations themselves with regard to the choice of one or more of the exponential functions contained therein, and

(e) excessive departure of the floor and ceiling surfaces from the ideal cosine law of reflection.

It is the author's opinion that the last-named possibility will account for most of the difference between observed and predicted values.

In order to evaluate the effect of possible errors in the measurement of the reflectance and transmittance of the wall cavity components on the equivalent reflectance of the vellum surface, several combinations of slightly different values of these constants were assumed and the equivalent reflect-

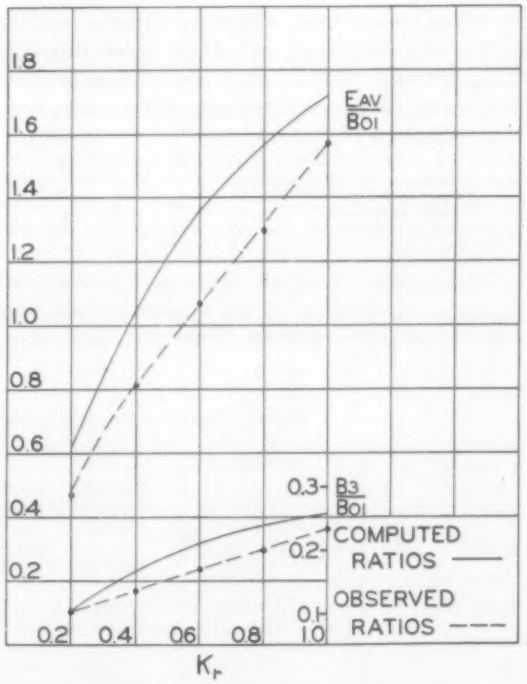


**Figure 3. The ratios $B_3/B_{01}$ and $E_{av}/B_{01}$.**

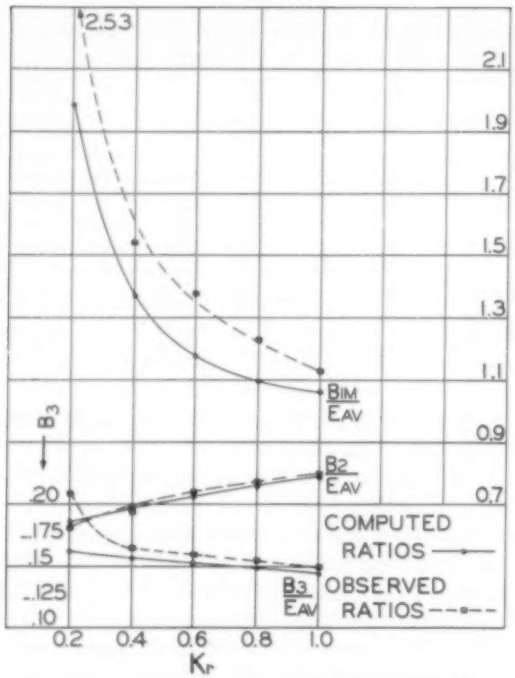


**Figure 4. The ratios $B_{1M}/E_{av}$, $B_2/E_{av}$ and $B_3/E_{av}$.**

ance recomputed. The results as shown below, indicate about one percentage point change in equivalent reflectance for two percentage points change in Masonite reflectance and vellum transmittance. As would be expected, vellum reflectance contributes to the equivalent reflectance more directly; two percentage points change in vellum reflectance producing two percentage points change in equivalent reflectance.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Masonite reflectance | .80 | .80 | .80 | .78 |
| Vellum reflectance | .41 | .41 | .39 | .41 |
| Vellum transmittance | .46 | .44 | .46 | .46 |
| Equivalent reflectance | .58 | .57 | .56 | .57 |

The possible effects of errors in the computed equivalent reflectance of the luminous walls have been investigated further. Using an equivalent reflectance of 0.56 instead of the value of 0.58 upon which the computations listed in Table I are based, the significant brightness ratios have been recalculated by means of the Moon-Spencer equations for two values of room ratio. The results are shown in Table II. It will be noted that for $k_r = 1.0$ (the cubical room) the ratio values are reduced about three per cent, while for $k_r = 0.4$ the reduction is about 1.5 to 2 per cent. In general, this reduction is not of significant effect in decreasing the gap between calculated and experimental values.

**TABLE II.**

| $k_r \longrightarrow$ | 1.0 | 0.4 | |
|---|---|---|---|
| $B_{1M}/B_{e1}$ | 1.83 | 1.45 | Calculated, $r = 0.58$ |
| | 1.78 | 1.42 | Calculated, $r = 0.56$ |
| | 1.78 | 1.26 | Observed |
| $B_2/B_{e1}$ | 1.36 | 0.732 | Calculated, $r = 0.58$ |
| | 1.32 | 0.72 | Calculated, $r = 0.56$ |
| | 1.23 | 0.565 | Observed |
| $B_3/B_{e1}$ | 0.254 | 0.168 | Calculated, $r = 0.58$ |
| | 0.247 | 0.165 | Calculated, $r = 0.56$ |
| | 0.235 | 0.135 | Observed |
| $E_{av}/B_{e1}$ | 1.72 | 1.05 | Calculated, $r = 0.58$ |
| | 1.67 | 1.04 | Calculated, $r = 0.56$ |
| | 1.57 | 0.82 | Observed |

There may be some question as to the validity of any conclusions drawn from test data taken in a model room of such small dimensions. Considering, however, the painstaking care with which the data were obtained and the obvious fact that the results when plotted show a fairly definite and logical trend the author is led to conclude that the Moon-Spencer equations for the luminous wall case need to be modified slightly to give results that are more in line with what can be expected in conventional full-scale interiors where the reflectances of all painted surfaces will doubtless depart considerably from the cosine law.

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## DISCUSSION

PHELPS MEAKER:* People who have really made a study of the requirements of light for living have recognized that there is an important field for luminous walls. Therefore, the setting up of design constants for wall sources is much more than an academic problem. Practical data are very much needed, if practitioners are to profit by the pioneering work that has been done.

Professor Bull, in using fluorescent lamps as the source behind his panels, may have assumed them to be quite invariable in output. Depending on the age of the lamps and the number of hours used, there might be a measurable depreciation during the course of his readings. Lamps that have been burned less than 1000 hours might be expected to depreciate at least 0.4 per cent during 100 hours, while at 5000 hours life the rate would be closer to 0.2 per cent. Such variations, however, do not appear to be significant contributors to any of the differences Professor Bull has reported.

On the other hand, variable ambient temperatures within the enclosures, and the adequacy of stabilization time for the lamps to reach steady conditions may be factors that contributed their part. The fact that the measurements of

*General Electric Co., Cleveland, Ohio.

$B_{01}$ were all made at the end of the series of room readings is disturbing; particularly as one is led to ask whether the ambient conditions were the same for both series of readings.

DOMINA EBERLE SPENCER:* It is my understanding that the investigation reported by Professor Bull was undertaken in order to see if the interflection equations for wall lighting can be experimentally verified. If such is the case, then the conditions assumed in the interflection theory should be employed and all known techniques for obtaining accurate experimental results should be utilized. The fact that highly accurate verification of the interflection equations for ceiling lighting was obtained in the careful work of Churchill and Putnam, while larger discrepancies are obtained by Bull when he ignores many of the laboratory precautions employed in the earlier work does not lead us to question the interflection equations. It leads us to question the accuracy of Professor Bull's measurements.

Consider first the reflectances of room surfaces. Professor Bull gives no data on the spectral reflectance. Yet as the grays were made by mixing two components it is fairly certain that they were not an achromatic set. Also these surfaces are called diffusing but no goniometric tests have been made. The only measurements of the reflectances of the surfaces are made with the Baumgartner reflectometer. This instrument is very useful in its place, but is not an accurate laboratory instrument. It measures reflectance as viewed in incandescent light and employs a photocell which has appreciable response in the infra-red. Such measurements are not applicable when fluorescent light is employed. The reflectance should have been obtained by measuring the spectral reflectance on a Hardy or General Electric spectrophotometer and calculating the total reflectance for the color of light actually used.

Rather than the incandescent lamps employed with great care by Churchill and Putnam, Professor Bull has used fluorescent lamps. Corrections for temperature, for aging, for wave form have been ignored. A correction for line voltage variation has been applied in a sporadic fashion.

Examination of Figs. 2 and 3 indicates the presence of random experimental errors of the order of 10 per cent as well as consistent experimental errors of 20 or 25 per cent. The data in Fig. 4 which contain measurements made with a magnesium oxide test plate indicate a progressively increasing error as the room becomes very shallow. For a cubical room, $k_r = 1$ theory and experiment are in reasonable agreement with errors $-8.6$ per cent, $+6.6$ per cent, $-0.6$ per cent, $+2.0$ per cent. As the room becomes progressively more shallow, the discrepancies increase until at $k_r = 0.2$ they are $-24.2$ per cent, $+25.9$ per cent, $-2.2$ per cent and $+27.2$ per cent. This is probably due to Professor Bull's assumption that the MgO disk is perfectly diffusing and has a reflectance of 0.97. Reference to Fig. 9.03 of Professor Moon's "Scientific Basis of Illuminating Engineering" shows that magnesium oxide is not a perfectly diffusing surface. In fact blotting paper or matte paint may be somewhat better approximations. At large angles of incidence the reflectance of the magnesium oxide disk may be as much as 30 per cent below the value assumed by Bull. At low values of $k_r$ most of the light falling on the MgO is from the walls and reaches the plate at large angles of incidence. This would amply explain the peculiar upward twist to the curves of Fig. 4.

The Bull paper serves to re-emphasize the difficulty of making accurate photometric measurements. It may, of course, be that the interflection equations for wall lighting are less accurate than those for ceiling lighting. But this cannot be established until measurements are made with the most precise techniques known today. This has not yet been done by Professor Bull. The indications are that uncertainties within his experimental data are as much as 20 or 30 per cent. Under these circumstances, the results of this paper do not in any way invalidate the predictions of the interflection theory.

ROBERT S. WISEMAN:* Two years ago, I presented a report of the results obtained from my experiments on interreflections in enclosures.[1] These experiments included studies of luminous walls which received the criticism of Dr. Spencer. Although I had analyzed the possible errors and their effects and showed that they would not explain all of the variation, Dr. Spencer was greatly concerned about the errors that experimenters make. Again she is unhappy with experimental results which do not agree with the theoretical data obtained from the equations she and Professor Moon derived. I think there is an undue concern about certain approximations that have to be made in experimental set-ups. Anyone who has ever done experimental work will realize the limitations imposed upon the experimenter.

At no time have I heard Dr. Spencer stress with the same invectiveness the fact that certain approximations had to be made in order to develop the theoretical equations and tables. Certain basic premises were formulated which are not strictly true in a physical enclosure. The surfaces are *not* perfectly diffusing. The medium within the enclosure is *not* transpar-

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*Engineer Research and Development Laboratories, Fort Belvoir, Va.

1. Wiseman, R. S.: Brightness and Illumination by Interflections in Enclosures," ILLUMINATING ENGINEERING, Vol. L, No. 5 (May 1955).

**Comparison of Experimental Techniques (Bull and Wiseman).**

| | Bull | Wiseman |
|---|---|---|
| lamps | fluorescent | incandescent |
| control | voltage | cells in walls and ceiling cavities as well as voltage |
| brightness | visible brightness meter | meter with barrier layer cell |
| surface brightness | measured with walls removed | measured with walls in place |
| illumination | MgO disc and visible brightness meter | specially designed color and cosine corrected cell |
| reflectances | Baumgartner reflectometer | Baumgartner, Spectrophotometric curve, & ratio of B-measured/E-measured |
| enclosure surfaces | vellum | sand-blasted Plexiglas |
| size | 3 feet x 3 feet | 6 feet x 6 feet |
| ceiling height | 1 foot to 4 feet | 3 feet to 6 feet |

ent and nondissipative — there will always be people and furniture. The initial brightnesses of each surface will *not* be uniform. Final ceiling and floor brightnesses are *not* uniform and the final brightness of the wall is *not* independent of the location around the wall. And, the kernel of the integral equation is *not* equal to an exponential function. So, before we begin thinking that the theoretical analysis is perfect, I think we should realize that the mathematical development is theoretical and does contain certain necessary and well-chosen approximations.

In analyzing Dr. Spencer's criticism of Professor Bull's method of experimentation, it is interesting to note the comparison of his experimental techniques with my own. (See table.)

Even though we used entirely different physical set-ups and used different photometric techniques, we both obtain basically the same results. And, if Professor Bull's data are plotted with mine and compared with the theoretical values, we are in good agreement and in only one particular point do we disagree. It is difficult to make some comparisons because we did not duplicate each other's physical dimensions and factors, but these two entirely different experiments lead to essentially the same average variations between experimental and theoretical data. Although both Professor Bull and I admit certain possible errors in our experiments, we are not able to explain the differences based on these errors and must conclude that the approximations made in the theoretical development must also contribute to the differences between experimental and theoretical values. The importance of these variations is analyzed in the paper I presented in this same session.[2]

2. Wiseman, R. S.: "Analysis of Experimental Data for Interflectance Theory." ILLUMINATING ENGINEERING, Vol. LII, No. 1 (January 1957).

H. S. BULL:* Mr. Meaker raises the question of changes in ambient temperature as having a possibly significant effect on the behavior of the fluorescent lamps used in the investigation. The experimental work was carried on in a windowless basement room where ambient temperatures were almost unvarying.

Dr. Wiseman's discussion is much appreciated and requires no comment.

The discussion presented by my good friend Dr. Spencer is very interesting, and of a pattern that is familiar to all who have at any time undertaken any research project that results in even minor criticism of the purely mathematical work done by Moon and Spencer. Stripped of excess verbiage it merely shows Dr. Spencer's distrust of all experimental techniques and her implicit and almost naive faith in the purely mathematical approach to all problems. In saying this I do not wish to belittle the importance of the mathematical work that Moon and Spencer have done in advancing our knowledge of the behavior of light in an enclosure. The opening paragraph of my paper was intended as a sincere tribute to their contributions.

It is quite possible that there is need for still another laboratory study of interflectances using, in her words, "the most precise techniques known today." I venture to predict that if this were done there would still be significant differences between the values obtained experimentally and those computed from the Moon-Spencer equations for luminous walls. I believe there is even greater need for a new mathematical approach in which an attempt is made to simulate the universally-recognized departure of all painted surfaces from the cosine law — perhaps assuming some form of ellipsoidal reflection pattern.

*Author.

## February 1 Is Deadline For 1957 Conference Paper Outlines

The I.E.S. Papers Committee has set a deadline of February 1 for outlines of proposed papers for the 1957 National Technical Conference.

Outlines of proposed papers, in triplicate, should be mailed to:

H. F. Davidson
Chairman, I.E.S. Papers Committee
c/o Hydro-Electric Power Commission of Ontario
620 University Avenue
Toronto 2, Ontario, Canada

# The Effect of Furniture on The Coefficient of Utilization

By DOMINA EBERLE SPENCER

FOR OVER FORTY YEARS the lumen method has been the cornerstone of practical lighting calculations. Originally, the coefficients of utilization were determined empirically on the basis of measurements made by Harrison and Anderson[1] in empty rooms. In the last fifteen years a theoretical foundation has been supplied by the interflection method.[2] It is now possible to calculate both the coefficient of utilization for any lighting installation and also the resulting distribution of light in the entire field of view. But the interflection method, in common with the earlier empirical work, is based on the assumption that the room contains no furniture or other irregularities.

Calculations based on the usual assumptions are ordinarily sufficiently accurate for the illuminating engineer. But if there are obstructions, such as beams, recesses, or furniture, the measured distribution of light may differ appreciably from that which is calculated. The purpose of this paper is to present a simple method by which irregularities in the room contours can be taken into account.

### Basic Procedure

The basic idea of this paper is that the effect of irregularities in room enclosures can be taken into account by the following two simple steps:

(A) Replace the actual room (which contains obstructions such as furniture, recesses and beams) with a fictitious unobstructed room having smooth concave walls, floor, and ceiling. This fictitious room actually satisfies the assumptions of the interflection method.

For example (Fig. 1), a beamed ceiling is replaced by a fictitious plane surface at the level of the bottom of the beams. In a drafting room with horizontal drafting tables, a fictitious floor is placed at the level of the table tops. If a room has recesses or ells, these are smoothed off in the fictitious room in such a way that the wall becomes everywhere concave.

(B) The equivalent reflectance of the fictitious wall, ceiling, and floor are found by

(1) Determining the equivalent reflectances of each recess,

(2) Averaging the equivalent reflectances of the recesses with the actual reflectances of wall, ceiling, or floor surfaces (weighting each with respect to area), to find average wall, ceiling, and floor reflectances which may then be used in applying the interflection method to the fictitious room.

Once the fictitious empty room has been sketched and equivalent reflectances have been determined, the procedure becomes routine, except that the principal surface on which we wish to calculate the number of lumens incident per unit area may be the *floor* of the fictitious room.

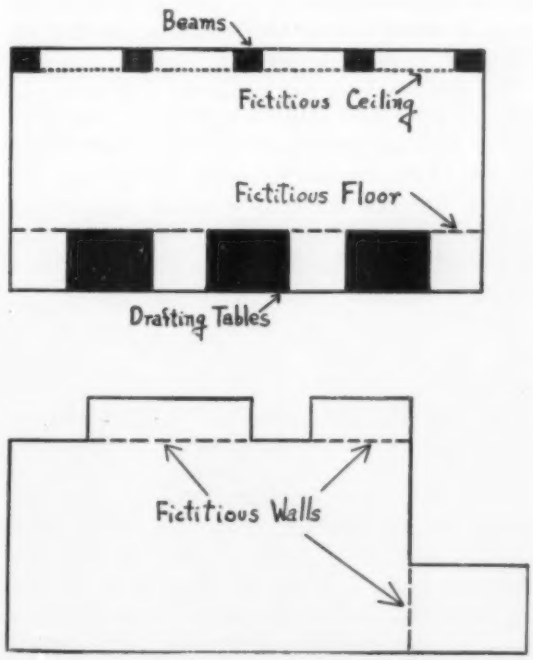


**Figure 1. A fictitious, empty room is imagined within the actual obstructed room.**

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHOR: Associate Professor, University of Connecticut, Storrs, Conn.; Consultant, Marlux Corp.

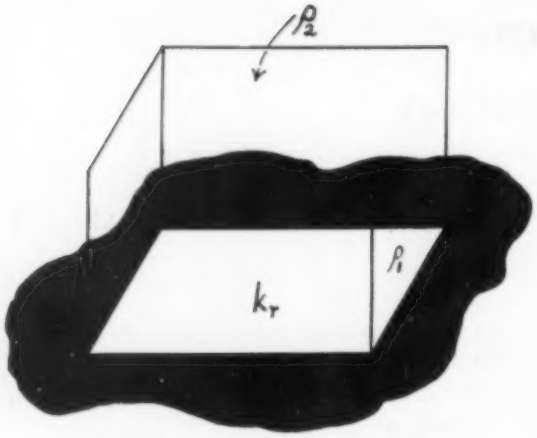


**Figure 2. A recess in a room surface.**

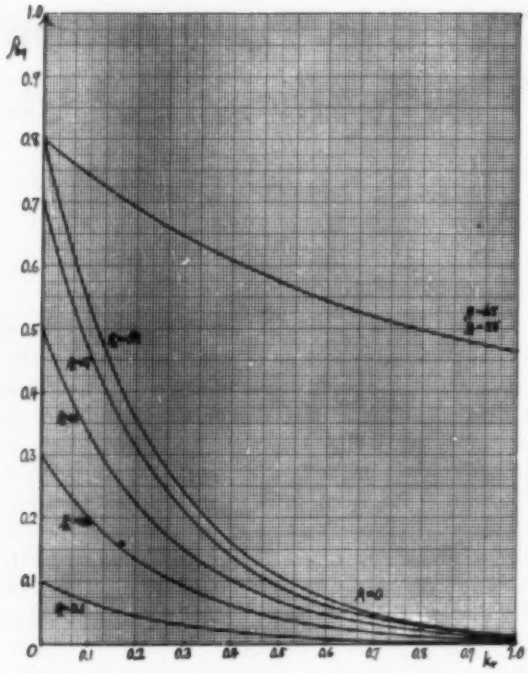


**Figure 3. Equivalent reflectance $\rho_{eq}$ of recess as a function of the $k_r$ of the recess for various reflectances.**

### Equivalent Reflectance of Recess

Consider a recess in a room surface (Fig. 2). It will be assumed that the recess has a concave cross-section (*i.e.* that every part of the recess can be seen from every other part of the recess). The shape of the recess can then be specified by the domance* $k_r$,

$$k_r = \frac{S_1}{4S}, \qquad (1)$$

where $S_1$ = wall area of recess,

$S$ = area of opening into recess.

The average reflectance of the sides or walls of the recess is called $\rho_1$; the reflectance of the top or ceiling of the recess is called $\rho_2$.

The problem is to determine the equivalent reflectance $\rho_{eq}$ of the recess. If light enters the opening of the recess diffusely and uniformly, what fraction of the incident light will emerge from the recess? But this is merely a special case of the interflection equations. The value of $\rho_{eq}$ is equal to that given by Eq. (23) on p. 469 of *Lighting Design*[3] for $\rho_3 = 0$ and $h' = h$. Thus,

$$\rho_{eq} = \frac{[\rho_1(1+\rho_2) - 2\rho_2]\sinh 2k_r\sqrt{1-\rho_1} + 2\rho_2\sqrt{1-\rho_1}\cosh 2k_r\sqrt{1-\rho_1}}{[2-\rho_1(1+\rho_2)]\ \sinh 2k_r\sqrt{1-\rho_1} + 2\sqrt{1-\rho_1}\cosh 2k_r\sqrt{1-\rho_1}} \qquad (2)$$

The way in which the equivalent reflectance $\rho_{eq}$ of a recess depends on $k_r$, $\rho_1$, and $\rho_2$ is illustrated in Fig. 3. Consider first a recess whose interior is painted white ($\rho_1 = \rho_2 = 0.80$). The equivalent reflectance varies from 0.80 for a very shallow recess ($k_r = 0$) to 0.46 for a cubical recess ($k_r = 1$). On the other hand, if the ceiling of the recess is white ($\rho_2 = 0.80$) while the walls of the recess are black ($\rho_1 = 0$), the equivalent reflectance for a cubical recess drops to 0.0147. Calculations can easily be made from Eq. (2) for each recess encountered.

### Application to Luminous Ceilings

Luminous ceilings are often installed below structural ceilings which contain numerous obstructions. The beams themselves may be exposed. Air-conditioning ducts, service pipes, sprinkling systems introduce further complications. Even though it is generally possible to paint all of these surfaces white, interflections among the obstructions will lower the output of the luminous ceiling substantially.

Consider a specific example in which a luminous ceiling contains the exposed beams shown in Fig. 4. The ceiling is crossed by a set of heavy beams 3 feet deep and 1 foot wide on 6-foot centers. Lamps are suspended from the bottom of the beams and the diffusing plastic is suspended 2 feet below the beams. The room is so large that it may be considered to be infinitely wide.

The first step is to find $k_r$ for the recess between the beams,

$$k_r = \frac{h(l+w)}{2lw}, \qquad (1a)$$

*This property has been referred to by others as room coefficient, or index of room proportion.

where $h = 3$ feet, $l = 5$ feet, $w \to \infty$. Thus,

$$k_r = h/2l = 3/10 = 0.3.$$

If all parts of the enclosure are painted white, $\rho_1 = \rho_2 = 0.80$, Eq. (2) shows that

$$\rho_{eq} = 0.647.$$

The average ceiling reflectance $\rho_5$ for the luminous ceiling plenum is found by taking a weighted average of the reflectance of the bottom of the beams and the equivalent reflectance of the recesses between the beams.

$$\rho_5 = \frac{1\,(0.80) + 5\,(0.647)}{6} = 0.673.$$

Thus the effect of the recesses between the beams is to lower the equivalent ceiling reflectance of the luminous ceiling plenum from 0.800 to 0.673. This in turn reduces the efficiency (logance), $g$, of the luminous ceiling, where

$$g = \frac{\text{lumens radiated from luminous ceiling}}{\text{lumens radiated from lamps}}.$$

In a very large room ($k_r = 0$), the values of $g$ are found from the simple equation[4]

$$g = \frac{\tau\,(1+\rho_5)}{2\,(1-\rho\rho_5)}, \qquad (3)$$

which gives (for a typical luminous ceiling diffusor with $\tau = 0.454$ and $\rho = 0.472$),

$$g = 0.657 \quad \text{if} \quad \rho_5 = 0.800,$$
$$g = 0.556 \quad \text{if} \quad \rho_5 = 0.673.$$

Thus, the beams serve to waste 15 per cent of the light. If the room is of finite size, $g$ is calculated from Eq. (16a) of "Interflections in Coupled Enclosures."[4]

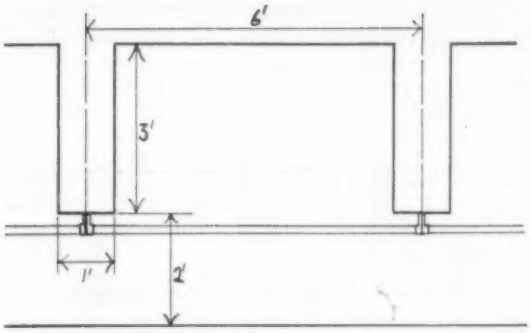


**Figure 4. A luminous ceiling obstructed by beams.**

The effect of varying the beam depth and the beam spacing in a situation similar to that of Fig. 4 is investigated in Fig. 5. Here the space between beams is $x$ times the beam width. Curves are shown for beams of depth 1, 2, and 3 times the beam width. All surfaces are white with reflectance of 0.8 and a very large, shallow luminous ceiling plenum ($k_r' = 0$) is employed. Fig. 5 gives the per cent reduction in the coefficient of utilization as a function of $x$. The error is never greater than 24 per cent and falls off rapidly as beam spacing increases. Nevertheless, many practical cases will be encountered in which the output of luminous ceilings may be reduced more than 10 per cent by the presence of beams or ducts above the lamps.

### The Effect of Furniture

Consider an office containing long rows of desks of reflectance 0.30 on top, 0.10 on the sides. Floor

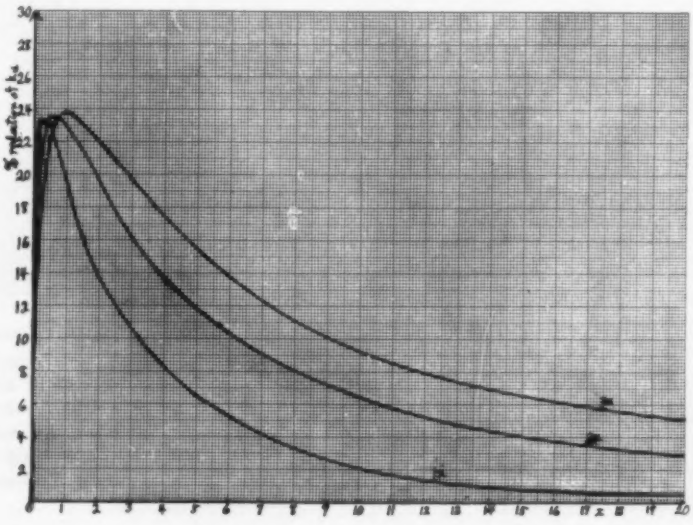

**Figure 5. Per cent reduction in coefficient of utilization of luminous ceiling associated with obstruction of light by beams above lamps versus beam spacing. Reflectance of beams and ceiling is 0.8. The spacing between beams is $x$ times beam width. Depth of beams is 1, 2, and 3 times beam width.**

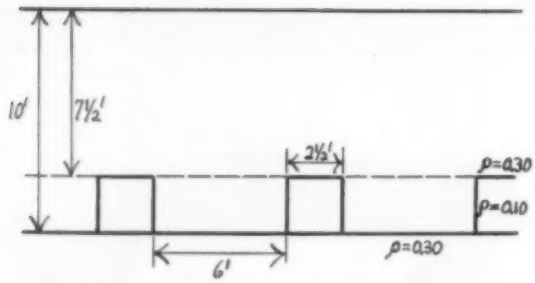


**Figure 6. A room obstructed by furniture.**

reflectance is 0.30. A cross-section is shown in Fig. 6. If the rows of desks are taken to be continuous, the value of $k_r$ for the recess between the desks is

$$k_r = \frac{2.5}{2(6)} = \frac{2.5}{12} = 0.208.$$

By Eq. (2), the equivalent reflectance of the space between the desks is ($\rho_1 = 0.10$, $\rho_2 = 0.30$),

$$\rho_{eq} = 0.151.$$

The average floor reflectance for the fictitious room with floor at desk-top level is

$$\rho_3 = \frac{(2.5)(0.3) + (6)(0.151)}{8.5} = 0.1948.$$

Consider a very large room, $k_r = 0$, lighted by a luminous ceiling with $g = 0.657$. Also,[3]

$$f = \frac{\rho_2}{1 - \rho_2\rho_3}. \qquad (4)$$

Assume $\rho_2 = 0.70$. Then

$$f = \frac{0.7}{1 - 0.7\,(0.1948)} = 0.811.$$

Taking into account the effect of the desks, the coefficient of utilization[3] is

$$k_u = fg = (0.811)\,(0.657) = 0.533.$$

If the furniture had been neglected, we would have had

$$\rho_3 = 0.30, \qquad f = 0.886, \qquad k_u = 0.582.$$

In this very large room the effect of the furniture is to reduce the coefficient of utilization by 8 per cent.

Next consider the same arrangement in a cubical room, $k_r = 1$, with wall reflectance 0.50. If we consider the effect of the furniture and employ the fictitious room of height 7½ feet instead of 10 feet, $k_r$ becomes 0.75. The value of $f$ is found by taking the value read from Table 5.04 of *Lighting Design* times the value read from Table 6.06 and dividing this product by $\rho_3$. From Table 5.04 we interpolate 0.519; from Table 6.06 we find 0.1471. Thus,

$$f = \frac{(0.519)\,(0.1471)}{0.1948} = 0.392,$$

$$k_u = (0.392)\,(0.657) = 0.258.$$

To calculate the coefficient of utilization for the same room, neglecting the effect of furniture, we would read $f$ from Table 5.04 of *Lighting Design* for $k_r = 1$, $\rho_1 = 0.50$, $\rho_2 = 0.70$, $\rho_3 = 0.30$. Then

$$f = 0.400 \quad \text{and}$$

$$k_u = (0.400)\,(0.657) = 0.263.$$

Furniture in the cubical room has reduced the coefficient of utilization by 2 per cent.

The worst possible case occurs when the reflectance of desk-tops and floor is high and the sides of the desks are black. As in Fig. 6, the height and width of the desks are equal. The separation of the desks is $x$ times the desk height. Fig. 7 shows the per cent reduction in coefficient of utilization as a function of $x$ when the reflectance of the sides of

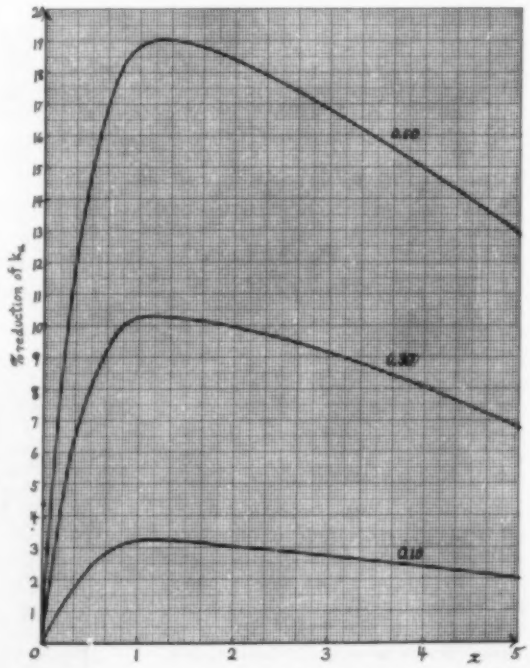


**Figure 7. Per cent reduction in coefficient of utilization in very large room lighted by luminous ceiling versus spacing of long rows of desks. Desk height equals desk width. Spacing between adjacent rows of desks is $x$ times the desk height. Equivalent reflectance of luminous ceiling is 0.70. Reflectance of sides of desks is zero. Reflectances of floor and of desk top are 0.50, 0.30 and 0.10.**

the desks is zero and reflectance of desk-tops and floor is 0.50, 0.30, and 0.10. For 50 per cent reflectance the discrepancy for a very large room may be as great as 19 per cent and occurs when the spacing between desks is slightly greater than desk height. For 30 per cent reflectance, the maximum error introduced by this furniture is slightly over 10 per cent. But if the reflectance is 10 per cent, the reduction associated with this furniture is always less than about 3 per cent. In small rooms the effect of furniture is much less than in large rooms.

## Conclusions

The paper has presented a simple method of taking into account the effect of irregularities in room enclosures. It has shown that, while the resulting reductions in coefficients of utilization are negligible in many practical cases, they may sometimes reach nearly 30 per cent. Beams above luminous ceilings have maximum effect when spacing between beams is of the same order of magnitude as beam width. Furniture has the greatest effect when reflectances are very high and when spacing is of the same order of magnitude as furniture dimensions. Thus, in applications in which furniture, beams, and other irregularities could be neglected in the days of low room reflectances, the modern trend toward high reflectances may require a more careful analysis. This is now made possible by use of the equation presented in this paper.

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## DISCUSSION

WILLARD ALLPHIN:* This paper seems to fill an important gap in the methods available for footcandle calculations. There are two questions I wish to ask. First, what is the relationship of the fictitious floor to the $k_r$ for the entire room? I should think that it would be the true ceiling height rather than height above the fictitious floor which would determine the $k_r$. Second, does Dr. Spencer feel that this method could be extended to cover nearly vertical drafting boards in rooms containing rows of these?

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GEORGE CLARK:* In discussing luminous ceilings, particularly the application design of them, in our training courses, we have successfully used a concept of two rooms to explain the parallel nature of the cavity or plenum and of the room of occupancy. We discuss reflectances, distribution of the luminaires, and shape of the cavity or the occupied room. At this point, however, we must depart from the "parallel" approach to point out the necessity of considering obstructions in the cavity. When the logical questions is raised regarding people and furniture in the occupied room, we have had to admit that we ignore that in the calculation of our illumination. Dr. Spencer's paper certainly gives us an approach to answer that kind of question.

It seems to me the greatest immediate value of the paper is that it gives a sounder basis for judgment of order of magnitude of the effect of furniture rather than necessarily the use of the method to make the rather complex computations for some of the extreme irregularities we frequently encounter.

The other question I would like to ask Dr. Spencer is what she considers to be the possibility of extending this concept to triangular cross-sections, thinking particularly, as I suspect many may, of saw-tooth roof constructions. We have had many who desire to use luminous ceilings or conventional luminaires for such areas. Another very general application of this nature is also the sloped ceiling room. Perhaps we could look forward to an extension of Dr. Spencer's approach to cope with those two problems.

W. S. FISHER:** My compliments to Dr. Spencer for her interesting application of the interflection formulas to this matter of furniture as it affects lighting. Her paper should be of value to those who have been curious about what furniture does to the illumination in a room. Certainly, it is helpful to know the order of magnitude of the reduction in coefficient of utilization for the typical rooms one encounters, and the several examples in the paper help to familiarize us with this matter.

One of Dr. Spencer's examples assumes desks in continuous rows with six feet between rows. This provides 42½ square feet per desk location. Many offices provide 75 to 80 square feet per desk not counting the space taken up by file areas and some other classes of space. With that much area the desks are not usually in continuous rows though this is a necessary assumption to the procedure of this method. Using Dr. Spencer's approach I solved the interflection equations assuming 80 square feet per desk with the desks in continuous rows, and found a five per cent reduction in coefficient of utilization as compared with the eight per cent figure in the paper, for 42½ square feet per desk. So, the five per cent to eight per cent range may be useful to keep in mind for the variety of offices one may encounter, varying from fairly open to crowded spaces, if the floor and furniture reflectances apply — and they are typical of many. When lighting efficiency is reduced by five per cent to eight per cent, it affects materially the economics of the lighting one may specify or buy, to say nothing of its possible effect on visual performance.

Some engineering data have recently been developed which may be useful in adjusting a known coefficient of utilization for various floor reflectances. These data are shown in the accompanying table. As indicated, they are multiplying factors used to adjust coefficients of utilization for a 10

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**General Electric Co., Nela Park, Cleveland, Ohio.

**Approximate Multiplying Factors for 30% Reflectance Floors.**
**(10% Reflectance Floor = 1.00)**

| Ceiling | | 80% | | | 70% | | | 50% | | | 30% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Walls | | 50% | 30% | 10% | 50% | 30% | 10% | 50% | 30% | 10% | 50% | 30% | 10% |
| Room Ratio | | | | | | | | | | | | | |
| 0.6 | (J) | 1.03 | 1.02 | 1.01 | 1.03 | 1.02 | 1.01 | 1.02 | 1.02 | 1.00 | 1.02 | 1.01 | 1.00 |
| 0.8 | (I) | 1.04 | 1.02 | 1.01 | 1.04 | 1.02 | 1.01 | 1.03 | 1.02 | 1.01 | 1.02 | 1.01 | 1.01 |
| 1.0 | (H) | 1.05 | 1.03 | 1.02 | 1.04 | 1.03 | 1.02 | 1.04 | 1.02 | 1.01 | 1.03 | 1.02 | 1.01 |
| 1.25 | (G) | 1.06 | 1.04 | 1.02 | 1.05 | 1.04 | 1.02 | 1.04 | 1.03 | 1.02 | 1.03 | 1.02 | 1.01 |
| 1.5 | (F) | 1.07 | 1.06 | 1.03 | 1.07 | 1.05 | 1.03 | 1.05 | 1.04 | 1.02 | 1.03 | 1.02 | 1.02 |
| 2.0 | (E) | 1.09 | 1.07 | 1.05 | 1.08 | 1.06 | 1.04 | 1.05 | 1.04 | 1.03 | 1.04 | 1.03 | 1.02 |
| 2.5 | (D) | 1.10 | 1.08 | 1.06 | 1.09 | 1.08 | 1.06 | 1.07 | 1.05 | 1.04 | 1.04 | 1.04 | 1.03 |
| 3.0 | (C) | 1.12 | 1.10 | 1.08 | 1.10 | 1.09 | 1.07 | 1.08 | 1.06 | 1.04 | 1.05 | 1.04 | 1.03 |
| 4.0 | (B) | 1.14 | 1.12 | 1.10 | 1.12 | 1.10 | 1.08 | 1.08 | 1.07 | 1.06 | 1.05 | 1.04 | 1.04 |
| 5.0 | (A) | 1.15 | 1.13 | 1.11 | 1.13 | 1.11 | 1.10 | 1.09 | 1.08 | 1.07 | 1.05 | 1.05 | 1.04 |

per cent floor reflectance to those for a 30 per cent reflectance. They are accurate within a few per cent for all types of lighting systems varying from luminous ceilings to troffers. For practical purposes it should be possible to interpolate to obtain multiplying factors for floors between 10 per cent and 30 per cent. So one might compute a fictitious floor reflectance according to the procedure of Dr. Spencer's paper and use the data of the table to find a multiplying factor which would correct a known coefficient of utilization for a 10 per cent reflectance floor to that of a room with the fictitious floor's reflectance.

Though one could not rigorously apply this scheme to any but large rooms because of the change in room ratio whereby the work plane becomes the floor of a fictitious new room, it is suggested as a *practical* device appropriate for application to many lighting problems.

PHILIP F. O'BRIEN and JAMES A. HOWARD:* As pointed out by Dr. Spencer, the prediction of the performance of lighting systems which are complicated by the inclusion of objects (*e.g.* beams, columns, furniture, machines, and human occupants) is a design problem which has largely been avoided because of its difficulty. Empirical methods for the treatment of this problem would obviously be very expensive because of the many possible combinations of geometry and surface reflectance of the objects within the enclosure. The method outlined in this paper will certainly be helpful to the serious lighting designer.

The equivalent reflectance of a square section recess as computed by Equation (2) of Dr. Spencer's paper is in error because of the exponential representation of the kernel. The existence and magnitude of this error was described by Professor Moon[1] in 1941, and recently, some authors[2,3] have referred to this exponential approximation of the shape modulus as a reason for the difference between empirical and calculated interflectance data. The use of Yamanti's[4] flux function or shape modulus to estimate this error was suggested by Moon[1] and was applied by Spencer[5] in 1954. A re-examination of this error using the shape modulus may be helpful to the appraisal of observed differences between empirical and analytical data, particularly in rooms of large domance (index of room proportion).

For the case of a square section recess, another expression for $\rho_{eq}$ may be derived by solving the continuity equations for flux at each surface of the recess. These expressions are:

$$L_1 = \frac{\rho_1 F_{1\to 2}\,(1+\rho_2 F_{2\to 3})\,L_{03}}{1-\rho_1\,[1-2F_{1\to 2}\,(1+2\rho_2 F_{2\to 1})]} \qquad (1)$$

$$L_2 = \rho_2\,[4F_{2\to 1}L_1 + F_{2\to 3}L_{03}] \qquad (2)$$

$$\rho_{eq} = \frac{4F_{3\to 1}L_1 + F_{3\to 2}L_2}{L_{03}} \qquad (3)$$

where:

$\rho_1, \rho_2$ — reflectances of recess walls and area opposite opening, respectively.

$L_1, L_2$ — average total luminous emittance of recess walls and ceiling, respectively.

$L_{03}$ — average initial luminous emittance of recess opening as viewed from inside of recess — flux input to recess.

$F_{n\to m}$ — the shape modulus — the fraction of flux leaving surface $n$ which is initially intercepted by surface $m$.

The following reciprocity relationship for fluxes is useful to the evaluation of Equations (1), (2) and (3):

$$A_n F_{n\to m} = A_m F_{m\to n} \qquad (4)$$

If the recess walls are black (*i.e.* $\rho_1 = 0$), the expression for $\rho_{eq}$ (Eq. 3) reduces to the following:

$$\rho_{eq} = [F_{3\to 2}]^2 \rho_2 \qquad (5)$$

Dr. Spencer's expression for $\rho_{eq}$ with black walls reduces to the following:

$$\rho_{eq} = e^{-4k_r}\rho_2 \qquad (6)$$

In order to show the difference between $\rho_{eq}$ as computed by the interflectance and the shape modulus methods, the value of $\rho_{eq}$ for various values of $\rho_1$ and $\rho_2$ is plotted as a function of domance (index of room proportion) in Fig. A. For the case of a recess with black walls ($\rho_1 = 0$) and white ceiling ($\rho_2 = 0.8$) and with $k_r = 1$, the equivalent reflectance computed by Dr. Spencer's expression ($e^{-4k_r}\rho_2$) is about 50 per cent lower than the value computed by the shape modulus expression ($F_{3\to 2})^2\ \rho_2 = (0.2)^2\,(0.8)$. With the highly reflecting walls and ceiling the equivalent reflectances as computed by the two methods are shown in Fig. A to be in close agreement. The solid line of Fig. A which is marked $\rho_1 = \rho_2 = 0.8$ is reproduced from the author's Fig. 3 while the data points were obtained using Equation (3) of this discussion.

The equivalent reflectance of a semi-infinite cavity between beams or rows of furniture is computed by Dr. Spencer using the same expression except that $k_r$ is reduced to $h/2l$ (where $h$ is recess depth and $l$ is the recess width while the recess length is infinite). The difference between the equivalent reflectance of a semi-infinite recess as computed by the author's expression, Equation (6), and by the shape-modulus

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expression, Equation (5) is shown in Fig. B. With black walls and $\rho_2$ of recess equal to 0.5 and $k_r = 1.0$, the $\rho_{eq}$ computed by the shape-modulus method is about three times larger than that computed by the expression which employs an exponential approximation of the shape modulus.

A convenient form of the shape modulus between the ceiling and opening of a semi-infinite recess is as follows:

$$F_{3\to 2} = \frac{1}{(l/h)}\left[\sqrt{(l/h)^2+1}-1\right]$$

$$F_{3\to 2} = \sqrt{1+4k_r^2}-2k_r$$

The data of Figs. A and B indicate that the equivalent reflectance of recesses of large $k_r$ and dark walls as computed by the exponential approximation of the shape modulus is significantly lower than the value computed by the exact shape modulus. This comparison of analytical data shows a per cent difference of the same order of magnitude as that observed between experimental results[2,3] and data based on the exponential approximation. As indicated above, the recess with large domance and dark walls is a limiting case and serves to define the maximum error associated with the exponential approximations of the shape modulus.


1. Moon, Parry: "Interreflections in Rooms," *Journal of the Optical Society of America*, Vol. 31, p. 374 (1941).
2. Wiseman, R. S.: "Brightness and Illumination by Interreflections in Enclosures," ILLUMINATING ENGINEERING, Vol. L, No. 5 (May 1955).
3. Bull, H. S. "Interflections in a Room with Luminous Walls," ILLUMINATING ENGINEERING, Vol. LII, No. 1 (January 1957).
4. Yamanti, Z.: "The Amount of Flux through Rectangular Windows," Electrot. Lab Tokyo, Researches 250, 1929. Also see Moon, Parry, "Scientific Basis of Illuminating Engineering," McGraw-Hill, pp. 334-344 (1936).
5. Spencer, D. E.: A discussion in ILLUMINATING ENGINEERING, Vol. XLIX, No. 3 (March 1954).


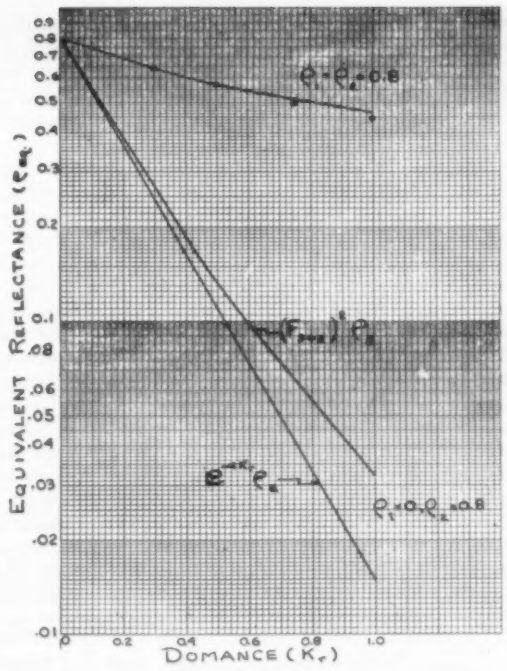


**Figure A. Equivalent reflectances $\rho_{eq}$ of a square sectioned recess as a function of $k_r$ of rececess for various reflectances. Data points for $\rho_1 = \rho_2 = 0.80$ were computed by network method.**

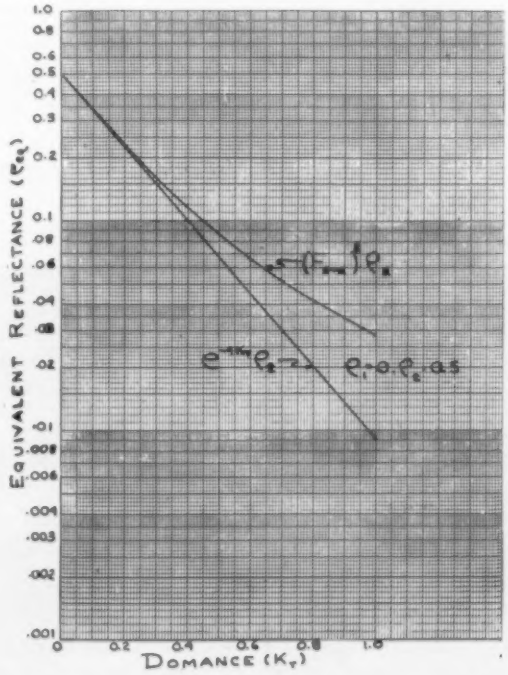


**Figure B. Equivalent reflectances $\rho_{eq}$ of a semi-infinite recess as a function of $k_r$ of recess for $\rho_1 = 0$ and $\rho_2 = 0.50$.**

DOMINA EBERLE SPENCER:* First I wish to thank Messrs. Allphin, Clark, Fisher, O'Brien and Howard for their valuable comments. This paper is merely a first step toward taking into account various types of irregularities. I hope that at some future conference others will extend the method and apply it to further important special cases.

Mr. Allphin, as usual, has a penetrating question and has brought up a point which I failed to take up in my presentation. It is pointed out in the paper that, when we place a fictitious floor at table level:

(1) We calculate $k_r$ for the part of the actual room above the fictitious floor,

(2) We determine the incident illumination on the desks from the tables for the brightness of the floor of the fictitious room:

$$D_{AV} = H_3/\rho_3$$

Actually, as the Society has found in forty years experience, this process is not necessary in most practical cases. For the introduction of furniture does two things. It lowers the equivalent floor reflectance and also the domance $k_r$ (index of room proportion) of the equivalent fictitious room. The former effect tends to lower the coefficient of utilization while the latter tends to compensate by raising the coefficient of utilization. For a wide range of practical cases the two effects cancel.

As to Mr. Allphin's rooms with nearly vertical drafting boards, that is another problem related to the one solved here, but not a direct consequence of it. The saw-tooth roof constructions and sloped roofs mentioned by Mr. Clark are

*Author.

another problem to which the general interflection procedures can and should be extended.

The additional examples provided by Mr. Fisher are useful. The practical import of this paper will probably be the use of better estimates of the effect of furniture and obstructions, such as he is employing.

The network representation method of handling interflection problems which has been developed by Mr. O'Brien is interesting and may give valuable approximations when applied to problems which have hitherto been considered too complicated for analytical treatment. It is, however, not an exact method for it makes the assumption that the brightness of each room surface is uniform. As the reflectances of our floors are practically always much lower than the reflectances of our ceilings, the lower part of the wall tends to be much darker than the upper part. Thus, this assumption is seldom justified. The Jones-Neidhart paper* makes nearly identical assumptions; the only difference is that Jones-Neidhart assume that all four walls of a room have an identical uniform brightness, while O'Brien does not requare that the four be identical. The interflection method permits the wall brightness to vary with distance above the floor and thus requires the solution of a set of simultaneous integral equations. This variation in wall brightness gives improved accuracy. On the other hand, the interflection method employs exponential kernels whose accuracy may be questioned in special cases. However, as pointed out in my discussion of the Jones-Neidhart paper, the inaccuracies associated with the exponential kernels can be largely eliminated by replacing the exponentials for direct light by the exact expression.

The information given in O'Brien's and Howard's Figs. A and B is correct, but in no way invalidates the procedures described in my paper. Let me repeat again that *the interflection method is meant to apply where there are interflections of light.* This necessitates high reflectances. Mr. O'Brien's curves would indicate that the expression for the equivalent reflectance of an enclosure which is derived from the basic interflection equations is accurate to within 10 per cent even if the walls of the enclosure are black, so long as the $\rho_{eq}$ remains above 0.15. If the equivalent reflectance of an irregularity in a room surface drops below this value, the fact that it may be pessimistic by a larger per cent is of no practical consequence. Whether a surface is of 1 or 2 per cent reflectance is of no importance. The distribution of light in the remainder of the enclosure would be essentially unchanged if this reflectance were taken as zero. It is only when the equivalent reflectance is high that the distribution of light in the enclosure is appreciably affected by errors in the magnitude of $\rho_{eq}$. Here *we need a precise specification* and *we have a precise specification in the equation presented in the paper.*

*To be published. Paper presented at the same session at the Boston Conference.

milj

**DECORATIVE MURALS in a restaurant are created by the use of fluorescent paints illuminated by black light from a 100-watt E-H1 mercury vapor lamp in a modification of a standard eyeball unit.**

**Against a matte black background in the dimly lighted room, the murals appear to be suspended in mid-air. The vivid colors with which they glow are, of course, not shown in this photo, which was developed from a color transparency.**

**This installation was the entry of A. D. Cohen, Lax Electric Co., Inc., St. Paul, Minn., in the I.E.S. Twin City Section's 1956 contest for My Most Interesting Lighting Job.**

# Analysis of Experimental Data For Interflectance Theory

By ROBERT SWERN WISEMAN

DURING THE past decade, several studies have been made of how light is interreflected in enclosures. Reports have been presented which tell of variations between measured values of illumination and brightness and those values calculated by the Interflectance Method which is based on theoretical equations. Most of the research has been on determining only the illumination on the work surface as reported by Potter, Russell, and Churchill.[1,2,3] Churchill and Putnam investigated not only the illumination but also the brightness distribution in the room for ceiling lighting components (from luminous ceilings or indirect lighting).[4] Bull investigated the illumination and brightness distribution for both wall and ceiling lighting components,[5,6] and the author presented results of illumination and brightness distribution for wall, ceiling, and floor lighting components.[7]

The purpose of this paper is to compare the results obtained by the various investigators and to illustrate the effects the indicated variations in each component have on the total. The data presented may be used as guides to determine what precautions need to be taken in designing the desired luminous environment. Average correction factors are shown for each reported investigation. The illumination and brightness distribution for three typical enclosures were calculated and variations of the uncorrected values from the corrected ones are reported. A comparison is made between the illumination as determined by the Lumen Method and the values obtained by the Interflectance Method. Observations are made of the effects of the correction factor data presented.

The ratio of the measured value to calculated value was determined for each reported test condition and is called the "correction factor." Thus, a calculated value multiplied by the appropriate correction factor will correspond to the measured values. The tables list the average correction factors for each report.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHOR: Chief, Research and Photometric Section, Night Vision Equipment Branch, Electrical Engineering Dept., Engineer Research and Development Laboratories, Fort Belvoir, Va.

Table I A shows the results obtained by Bull and by the author for wall lighting components. Table I B lists the average correction factors for ceiling lighting components with the weighted average for the data obtained by Bull and by the author. The only significant variation of Churchill's results from Bull's and the author's is in the ratio of $B_{1m}/E$. If Churchill's data are included in the weighted average, the value of $B_{1m}/E$ would be 0.87 instead of 0.79. Since other data were not available for

**TABLE I A — Wall Lighting Component Correction Factors.**

| Experimenter | Bull #1[5] | Bull #2[6] | Wiseman[7] | Weighted Average** |
|---|---|---|---|---|
| No. of tests | 6 | 5 | 3 | |
| $k_r$ range* | 0.25-1.0 | 0.2-1.0 | 0.5-1.0 | |
| Reflectance | Not | | | $\frac{5B\#2+3W}{8}$ |
| Wall | reported | 0.58 | 0.70 | |
| Ceiling | 0.80 | 0.84 | 0.68 | |
| Floor | 0.09 | 0.15 | 0.30 | |
| $f$ or $E/B_{01}$ | —— | 0.81 | 0.85 | 0.82 |
| $B_{1m}/E$ | 1.14 | 1.14 | 1.17 | 1.16 |
| $B_2/E$ | 1.18 | 0.99 | 0.97 | 0.98 |
| $B_3/E$ | 0.95 | 1.03 | 1.00 | 1.02 |
| $B_{1m}/B_{01}$ | —— | 0.93 | 1.00 | 0.95 |
| $B_2/B_{01}$ | —— | 0.80 | 0.82 | 0.81 |
| $B_3/B_{01}$ | —— | 0.87 | 0.85 | 0.86 |

*$k_r = \frac{\text{width} + \text{length}}{2\ (\text{width})\ (\text{length})}$ (room height).

**Weighted average of data for five test conditions reported by Bull in his second research and three test conditions by Wiseman.

**TABLE I B — Ceiling Lighting Component Correction Factors.**

| Experimenter | Churchill & Putnam[4] | Bull #1[5] | Wiseman[7] | Weighted Average** |
|---|---|---|---|---|
| No. of tests | 6 | 5 | 6 | |
| $k_r$ range* | 0.2-1.0 | 0.3-1.0 | 0.5-1.0 | |
| Reflectance | | | | $\frac{5B\#1+6W}{11}$ |
| Wall | 0.85 | 0.55 | 0.55-0.70 | |
| Ceiling | 0.65 | 0.61 | 0.68 | |
| Floor | 0.27 | 0.21 | 0.30 | |
| $f$ or $E/B_{03}$ | 1.00 | (1.00) | 0.97 | 0.97 |
| $B_{1m}/E$ | 1.00 | 0.78 | 0.81 | 0.79 |
| $B_2/E$ | 1.01 | 0.94 | 0.99 | 0.97 |
| $B_3/E$ | 1.01 | 1.05 | 1.05 | 1.05 |

*$k_r = \frac{\text{width} + \text{length}}{2\ (\text{width})\ (\text{length})}$ (room height).

**Weighted average of data for five test conditions reported by Bull in his first research and six test conditions reported by Wiseman.

**TABLE I C — Floor Lighting Component Correction Factors.**

| Experimenter | Wiseman[7] |
|---|---|
| No. of tests | 6 |
| $k_r$ range | 0.5-1.0 |
| Reflectance | |
| Wall | 0.55-0.70 |
| Ceiling | 0.30 |
| Floor | 0.68 |
| $f$ or $E/B_{22}$* | 0.77 |
| $B_{1m}/E$** | 1.06 |
| $B_2/E$** | 1.31 |
| $B_3/E$** | 1.23 |
| $B_{1m}/B_{22}$ | 0.82 |
| $B_2/B_{22}$ | 1.02 |
| $B_3/B_{22}$ | 0.95 |

*Direct flux to work surface from luminaires considered as a separate component.
**Direct lighting tables[8] are based on $E$ calculated using $f = 1+f_3$.

**Definition of Symbols**

1 — reference number for wall surfaces
2 — reference number for ceiling surfaces
3 — reference number for floor surfaces
$WS$ — reference for work surface defined as a horizontal plane one-quarter of the ceiling height from the floor
$B_{21}$ — initial wall brightness (footlamberts)
$B_{22}$ — initial ceiling brightness
$B_{23}$ — initial floor brightness
$B_{1m}$ — final wall brightness along line midway between ceiling and floor (footlamberts)
$B_2$ — final ceiling brightness
$B_3$ — final floor brightness
$F_1$ — initial lumens from luminaires to wall
$F_2$ — initial lumens from luminaires to ceiling
$F_3$ — initial lumens from luminaires to floor
$f_1$ — interflectance factor (utilization factor) for wall lighting. Per cent of initial lumens from wall that finally are incident on the work surface
$f_2$ — interflectance factor for ceiling lighting. Per cent of initial lumens from ceiling that finally are incident on the work surface
$f_3$ — interflectance factor for floor lighting. Per cent of initial lumens from floor that are finally incident on work surface. The direct flux from the luminaires to the work surface is considered as a separate component.
$k_r$ — room index $= \dfrac{\text{width}+\text{length}}{2\,(\text{width})\,(\text{length})} \times$ room height

floor lighting, the results found by the author have been used as the average in Table I C.

Table II summarizes the average correction factors determined from the measured and calculated data for work surface illumination as reported by various investigators. It may be concluded from the evidence that calculations of work surface flux from the ceiling lighting component or luminous ceilings will be quite accurate.

Table III lists the correction factors used in this paper. Since the lumens which originate from the luminaires and are initially reflected by the floor, are then interreflected, and finally are incident on the work surface will be small in comparison to the lumens which go from the luminaires direct to the work surface, the 0.77 correction factor for the floor component of the interflectance factor has little influence on the total.

In order to determine how the variations in each component would affect the total values of illumination and brightness, sample problems were solved by assuming luminaires with mathematical distributions mounted in three room shapes.

**TABLE II — Correction Factors for Ceiling Lighting Component of Interflectance Factor.**

| Experimenter | No. of Test | Average Correction Factor |
|---|---|---|
| | LUMINOUS CEILING | |
| Churchill & Putnam[4] | 6 | 1.00 |
| Bull #1[5] | 5 | 1.00 |
| Wiseman[7] | 6 | 0.97 |
| Russell & Churchill[6] | 8 | 1.03 |
| | INDIRECT LUMINAIRES | |
| Potter & Russell[1] | 6 | 1.13 |
| Potter & Russell[2] | 8 | 1.06 |

Room A: $k_r = 1.0$ (10 ft × 10 ft × 10 ft)
One luminaire in center of room, mounting height from floor 8 ft.

Room B: $k_r = 0.5$ (20 ft × 30 ft × 12 ft)
Two rows of three luminaires each, mounting height from floor 9 ft.

Room C: $k_r = 0.2$ (40 ft × 120 ft × 12 ft)
Four rows of twelve luminaires each, mounting height from floor 10 ft.

Luminaires with the following mathematical distributions were assumed to be used with each of the three rooms.

Cosine Direct: $I_\theta = 100 \cos\theta$ $\quad (0° \leq \theta \leq 90°)$
Uniform: $I_\theta = 100$
Cosine Indirect: $I_\theta = 100\,|\cos\theta|$ $\quad (90° \leq \theta \leq 180°)$

The sample problems differ from the premises established for the Interflectance Method and experimental tests by not having the enclosure surface completely uniform in initial brightness. The theoretical initial uniformity of brightness will not be obtained whenever luminaires are used instead of self-luminous surfaces.

Data were obtained by calculating, mathematically, the initial flux distribution from the luminaires to the walls, ceiling, floor, and work surface. The final work surface flux was then calculated by using the appropriate interflectance factors[8] both with and without their respective correction factors (Table III). The wall, ceiling, and floor brightnesses were then calculated by multiplying each illumination value, uncorrected and corrected,

**TABLE III — Component Correction Factors Used in Calculations.**

| | Via Walls | Via Ceiling | Via Floor |
|---|---|---|---|
| Interflectance Factor | 0.82 | 0.97 | 0.77 |
| $B_{1m}/E$ | 1.16 | 0.79 | 1.06 |
| $B_2/E$ | 0.98 | 0.97 | 1.31 |
| $B_3/E$ | 1.02 | 1.05 | 1.23 |

**TABLE IV — Representative Distribution of Interreflected Flux. Per Cent of Total Flux Incident on Indicated Surfaces as Contributed by Component Flux from Luminaires and Corrected with Correction Factors. Reflectances: Ceiling 80%, Walls 50%, Floor 30%**

| | Cosine Direct | | | Uniform | | | Direct | Cosine Indirect | |
|---|---|---|---|---|---|---|---|---|---|
| | Via Walls | Via Floor | Direct to W. S. | Via Walls | Via Ceiling | Via Floor | to W. S. | Via Walls | Via Ceiling |
| | $k_r = 1.0$ | | | | | | | | |
| Initial Distribution | 67 | 33 | 51 | 58 | 33 | 9 | 15 | 12 | 88 |
| Final Flux to Work Surface | 17 | 2 | 81 | 26 | 30 | 1 | 43 | 6 | 94 |
| Final Flux to Walls | 90 | 10 | — | 74 | 23 | 3 | — | 20 | 80 |
| Final Flux to Ceiling | 78 | 22 | — | 19 | 79 | 2 | — | 2 | 98 |
| Final Flux to Floor | 25 | 75 | — | 36 | 29 | 35 | — | 8 | 92 |
| | $k_r = 0.5$ | | | | | | | | |
| Initial Distribution | 46 | 54 | 65 | 48 | 34 | 18 | 23 | 12 | 88 |
| Final Flux to Work Surface | 14 | 6 | 80 | 21 | 34 | 3 | 42 | 6 | 94 |
| Final Flux to Walls | 80 | 20 | — | 71 | 23 | 6 | — | 23 | 77 |
| Final Flux to Ceiling | 50 | 50 | — | 20 | 74 | 6 | — | 3 | 97 |
| Final Flux to Floor | 17 | 83 | — | 26 | 35 | 39 | — | 7 | 93 |
| | $k_r = 0.2$ | | | | | | | | |
| Initial Distribution | 26 | 74 | 81 | 28 | 44 | 28 | 32 | 3 | 97 |
| Final Flux to Work Surface | 8 | 12 | 80 | 12 | 43 | 5 | 40 | 1 | 99 |
| Final Flux to Walls | 70 | 30 | — | 63 | 28 | 9 | — | 9 | 91 |
| Final Flux to Ceiling | 25 | 75 | — | 12 | 76 | 12 | — | 1 | 99 |
| Final Flux to Floor | 10 | 90 | — | 14 | 44 | 42 | — | 1 | 99 |

by its respective uncorrected and corrected $B/E$ ratios.[8]

The components were then added to obtain the total illumination and brightness values for each condition. Per cent variations between uncorrected and corrected totals, as well as the per cent of each total that was contributed by each component, were calculated. Data were obtained of work surface flux (illumination) and wall, ceiling, and floor brightnesses for combinations of: $kr$ (Room Index) = 0.2, 0.5 and 1.0; wall reflectances 0.80, 0.50, 0.30 and 0.10; ceiling reflectances 0.80, 0.70, and 0.50; and floor reflectance 0.30. The results of these calculations are summarized in Tables IV through VII.

A representative final distribution of interreflected flux from the luminaires is shown in Table IV. Fortunately, the largest correction factors occur where their effects are small. The largest correction for the interflectance factor (utilization factor) is for the floor lighting component (0.77), and it is shown in this table that, of the final flux to the work surface, only a small percentage (1 to 12 per cent) is contributed by this component and that the direct flux from luminaires to work surface will always be considerably greater than (5 to 40 times) the interreflected initial floor flux. The apparent large correction factors for $B_2/E$ and $B_3/E$ for floor lighting are simply the results of the variation in $f_3$ or $E/B_{03}$ being in the denominator of the ratios since the basic ratios of $B_2/B_{03}$ and $B_3/B_{03}$ are divided by $E/B_{03}$ to obtain the ratios of $B_2/E$ and $B_3/E$.

**TABLE V — Per Cent Error of Work Surface Lumens Caused by Assuming the Direct Flux to Work Surface Equal to Direct Flux to Floor. Reflectance: Ceiling 50% to 80%; Floor 30%**

| | Cosine Direct | | | Uniform | | |
|---|---|---|---|---|---|---|
| $k_r$ | 1.0 | 0.5 | 0.2 | 1.0 | 0.5 | 0.2 |
| $F_1$ | 67% | 46% | 26% | 58% | 48% | 28% |
| $F_2$ | 0% | 0% | 0% | 33% | 34% | 44% |
| $F_3$ | 33% | 54% | 74% | 9% | 18% | 28% |
| $F_{ws\text{-}D}$ | 51% | 65% | 81% | 15% | 23% | 32% |
| Wall Reflectance | | | | | | |
| 0.8 | −22% | −11% | −6% | −11% | −8% | −4% |
| 0.5 | −28 | −13 | −6 | −18 | −10 | −5 |
| 0.3 | −32 | −14 | −7 | −22 | −12 | −5 |
| 0.1 | −34 | −15 | −7 | −27 | −14 | −5 |

There are two ways to calculate the work surface flux from the floor lighting component. The original method was to assume the flux direct from the luminaire incident on the work surface equal to the direct flux to the floor, and this was added to the interreflected floor flux: $(F_{ws})_3 = F_3 f'_3 = F_3(1+f_3)$. This method neglects that flux which is incident on the work surface and falls on the lower quarter of the walls. The second method is to calculate the flux that is directed from the luminaires to the work surface and add this to the interreflected flux as a separate component: $F_{ws} = F_{ws}\text{-direct} + F_3 f_3$. The value of $f_3$ is found by subtracting unity from the $f'_3$ values recorded in Table XIV, *Lighting Design by the Interflectance Method*.[8]

Table V shows the error caused by assuming the direct flux to the work surface equal to the direct flux to the floor.

Table VI shows the effects of the component cor-

**TABLE VI — Per Cent Variation of Uncorrected Work Surface Flux from That Corrected with Correction Factors.* Reflectance: Floor 30%**

| | | Cosine Direct | | | Uniform | | | Cosine Indirect | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Luminaire Distribution (% Total) | $k_r$ | 1.0 | 0.5 | 0.2 | 1.0 | 0.5 | 0.2 | 1.0 | 0.5 | 0.2 |
| | $F_1$ | 67% | 46% | 26% | 58% | 48% | 28% | 12% | 12% | 3% |
| | $F_2$ | 0% | 0% | 0% | 33% | 34% | 44% | 88% | 88% | 97% |
| | $F_3$ | 33% | 54% | 74% | 9% | 18% | 28% | 0% | 0% | 0% |
| | $F_{w-D}$ | 51% | 65% | 81% | 15% | 23% | 32% | 0% | 0% | 0% |
| Ceiling Reflectance | Wall Reflectance | | | | | | | | | |
| 0.8 | 0.8 | +9 | +9 | +7 | +11 | +9 | +7 | +5 | +5 | +3 |
| | 0.5 | 4 | 5 | 5 | 7 | 7 | 6 | 4 | 4 | 3 |
| | 0.3 | 2 | 3 | 4 | 5 | 4 | 4 | 4 | 4 | 3 |
| | 0.1 | 1 | 1 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| 0.5 | 0.5 | 4 | 4 | 4 | 7 | 6 | 5 | 5 | 5 | 3 |
| | 0.3 | 2 | 2 | 3 | 5 | 4 | 4 | 4 | 4 | 3 |
| | 0.1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

*The true direct work surface flux was used in all calculations.

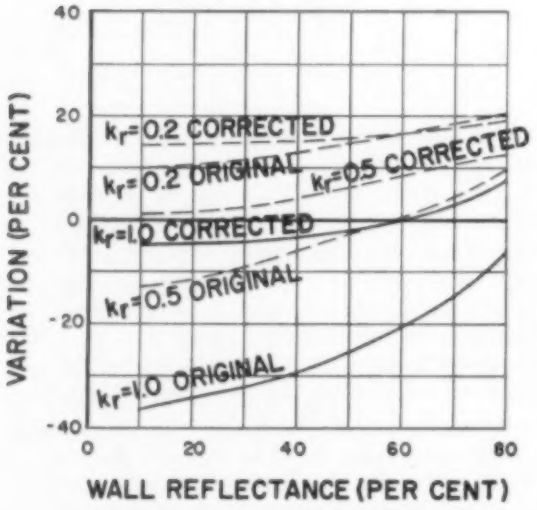


**Figure 1. Cosine direct distribution.**

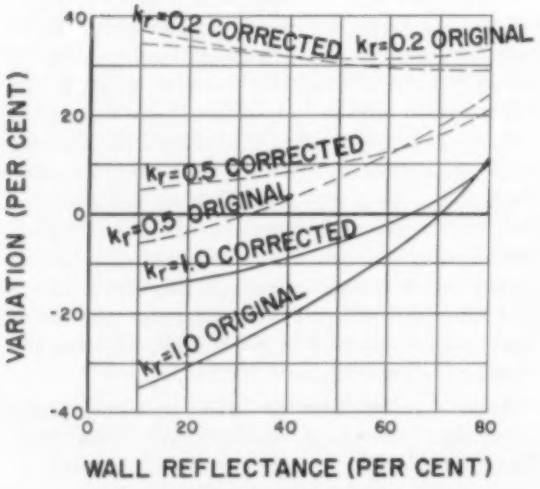


**Figure 2. Uniform distribution.**

rection factors on the total final illumination or work surface flux values, and Table VII shows the variations of the final brightness values from uncorrected to corrected component ratios.

Since the Lumen Method of calculating the illumination on the work surface has been employed for many years, it was felt that a comparison of the variations of calculated values of illumination obtained by the Lumen Method[9] and both uncorrected and corrected Interflectance Factors would be of interest. Table VIII and Figs. 1, 2 and 3 show

**Figures 1, 2 and 3. Curves of per cent variation of work surface lumens calculated by Interflectance Method compared to values obtained by Lumen Method. Reflectances: Ceiling 80%; Floor 30%.**

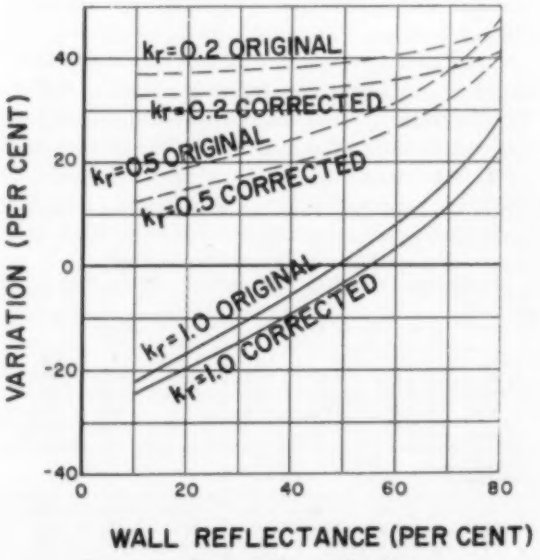


**Figure 3. Cosine indirect distribution.**

**TABLE VII — Per Cent Variation of Uncorrected Brightness Values from Corrected Brightness Values. Reflectance: Ceiling 50% to 80%, Floor 30%**

| $k_r$ | Cosine Direct 1.0 | 0.5 | 0.2 | Uniform 1.0 | 0.5 | 0.2 | Cosine Indirect 1.0 | 0.5 | 0.2 |
|---|---|---|---|---|---|---|---|---|---|
| Wall Reflectance | Variation of Uncorrected Wall Brightness | | | | | | | | |
| 0.8 | +7 | +9 | +10 | +11 | +11 | +13 | +25 | +23 | +28 |
| 0.5 | 7 | 9 | 10 | 11 | 11 | 13 | 24 | 23 | 28 |
| 0.3 | 7 | 8 | 10 | 10 | 11 | 13 | 24 | 23 | 28 |
| 0.1 | 7 | 8 | 10 | 10 | 11 | 13 | 24 | 23 | 28 |
| | Variation of Uncorrected Ceiling Brightness | | | | | | | | |
| 0.8 | +20 | +14 | +8 | +12 | +11 | +9 | +7 | +7 | +6 |
| 0.5 | 19 | 12 | 5 | 10 | 9 | 8 | 7 | 7 | 6 |
| 0.3 | 17 | 9 | 3 | 8 | 8 | 7 | 6 | 7 | 6 |
| 0.1 | 11 | 4 | 1 | 7 | 7 | 6 | 6 | 6 | 6 |
| | Variation of Uncorrected Floor Brightness | | | | | | | | |
| 0.8 | +12 | +10 | +8 | +10 | +8 | +5 | 0 | 0 | −1 |
| 0.5 | 9 | 8 | 7 | 9 | 7 | 5 | 0 | 0 | −1 |
| 0.3 | 8 | 7 | 6 | 7 | 6 | 4 | 0 | −1 | −2 |
| 0.1 | 6 | 6 | 6 | 5 | 4 | 3 | −1 | −1 | −2 |

the variations for the three luminaires and three room ratios used in the sample problems. The largest ranges of variations are obtained when the direct flux to the work surface is assumed to be equal to the direct flux to the floor. The additional effect of the correction factors is to decrease the slopes of the curves of variations which means the ranges of variations are decreased.

Analysis of the tables presented in this paper indicates the following general observations. The direct flux from luminaires to work surface should be determined exactly and should not be considered equal to the direct flux to the floor. If this distinction is made, only the decimal part of the values for the floor lighting component interflectance factor when reported as greater than unity[8] should be used. However, because of the construction of the remaining floor lighting brightness tables[8] ($B/ = B/B_{02} \div E/B_{02}$), the illumination value used to multiply $B_1/E$, $B_2/E$ and $B_3/E$ must be calculated by using the value of illumination determined by the interflectance factor as reported in that same set of tables.

**TABLE VIII — Comparison of Illumination Calculated by Interflectance and Lumen Methods. Per Cent Variation of Work Surface Lumens as Calculated by Interflectance Method Compared To the Value Obtained by Lumen Method.**

| | Cosine Direct | | | Uniform | | | Cosine Indirect | |
|---|---|---|---|---|---|---|---|---|
| | Orig. | $F_{w\,s-d}$ Corr. | All Corr. | Orig. | $F_{w\,s-d}$ Corr. | All Corr. | Orig. | All Corr. |
| | Reflectances: Ceiling 80%, Walls 50%, Floor 30% | | | | | | | |
| $k_r = 1.0$ | −25 | + 3 | − 2 | −15 | + 1 | − 5 | + 1 | − 4 |
| $k_r = 0.5$ | − 3 | +11 | + 6 | + 8 | +18 | +11 | +27 | +22 |
| $k_r = 0.2$ | +15 | +22 | +16 | +32 | +38 | +30 | +39 | +35 |
| | Reflectances: Ceiling 50%, Walls 30%, Floor 30% | | | | | | | |
| $k_r = 1.0$ | −32 | − 1 | − 3 | −28 | − 6 | −10 | −10 | −14 |
| $k_r = 0.5$ | −10 | + 5 | + 2 | − 1 | +13 | + 9 | +22 | +17 |
| $k_r = 0.2$ | + 7 | +15 | +12 | +23 | +31 | +26 | +30 | +25 |

The variations in the totals for the work surface illumination are small compared to the variation caused by using the incorrect direct flux or the values obtained from the Lumen Method. As expected, the indirect or luminous ceiling type lighting has the least variation, and the variations caused by the wall and floor components are masked by the relatively large amount of direct illumination on the work surface.

The significance of the indicated variations of the uncorrected brightness values will depend upon the care with which the luminous environment is being designed and the accuracy with which the recommended brightness limitations and ratios are known. It is hoped that the data presented in this paper will furnish a basis for a more realistic understanding of the effects of the correction factors to the Interflectance Method.


## Acknowledgments

Appreciation is expressed for the assistance of Mr. Joseph S. Bunor in performing some of the many lengthy calculations from which the data presented have been condensed.


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## DISCUSSION

DOMINA EBERLE SPENCER:* My comments on Professor Bull's paper and on Dr. Wiseman's paper last year have already indicated that I do not consider that their experimental techniques justify the calculation of "correction factors" for the interflection tables. An illustration of the magnitude of possible discrepancies is shown in Table IB. For $H_{1M}/D_{av}$ Churchill and Putnam are in exact agreement with the interflection prediction. On the other hand, Bull is low


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by 22 per cent and Wiseman by 19 per cent. This indicates a serious discrepancy. Yet Dr. Wiseman proceeds to throw away the excellent Churchill-Putnam data and to suggest a correction factor based on the average of the Bull and Wiseman data. The suggested correction factors of up to 31 per cent are of the same order of magnitude as the probable uncertainties in the Bull and Wiseman data.

The tendency for experimenters to believe that their data are more precise than is later found justified is a common one. Michaelson often gave an experimental result with an estimated accuracy only to find on repeating the experiment that the new value differed from the old value by several times the supposed margin of error. A study of the values of the velocity of light accepted internationally as a function of time shows the same trend.

It would, of course, be very nice if a Churchill or a Putnam would make definitive tests on the wall and floor components of the interflection method. On the other hand, the matter is not an urgent one. Predictions of the interflection method are almost certainly as accurate as practical photometric measurements. And, as Dr. Wiseman has pointed out, the accuracy of the data for wall and floor lighting has comparatively little effect on most practical lighting calculations. It is certain that there is no urgent need for correction factors. It remains probable that correction factors will never be needed. And as photometric accuracy to 5 per cent or 1 per cent is practically meaningless in lighting design, the entire problem is more academic than real.

HEMPSTEAD BULL:* This paper merits careful study. It brings together, on a comparative basis, the interflection data obtained experimentally by several investigators using somewhat different techniques, and offers some worthwhile suggestions with regard to correction factors that may be applied to improve the accuracy of predicting brightness and illumination ratios.

I was particularly interested in the material presented in Table V, and in the comparison between the results obtained with the lumen method and the interflectance method for certain idealized types of light sources.

PHELPS MEAKER:** Dr. Wiseman is to be complimented on making it pretty clear at the outset that his analysis is not undertaken with a view to "verifying" the interflection mathematics. There has been quite a bit of doubt in my mind, and I venture to say in the minds of others as well, just what some of these researches were attempting to establish. There is an understandable urge to make an experimental set-up to check the results of mathematics. However, when such tests have been analyzed, failures to agree have been blamed on the virtual impossibility of building perfectly diffusing and completely uniform panels and perfectly diffusing reflecting surfaces, all having reflectances known with absolute accuracy. So the practical result of these studies has been to furnish data to answer the question: "How well does the theoretical treatment match measurements made under the most practical duplication of assumed conditions?"

On the other hand, since the experimental rooms have been constructed to reproduce the assumptions as closely as possible, it may be asked whether they truly represent practical conditions. If any further studies are undertaken, it is urged that a great deal more thought be given to recording the actual conditions as to diffusion and brightness uniformity, as well as reflectance. As it is, even Dr. Wiseman will probably say that he is unable to determine what part of the correction factors are attributable to experimental conditions, and what part to the acknowledged approximations in the Moon and Spencer theory.

There is an unfortunate tendency to label different procedures by pet names, giving the impression that completely different concepts are involved. For instance, nothing could be more incorrect than to assume that the Harrison-Anderson "Lumen Method" did not recognize interflections — even though they were not treated as such by name. Nor could the "Interflection" tables be applied to anything other than highly diffusing luminous surfaces without reliance on some sort of "lumen method" for analyzing the luminaire output.

It is too bad that Dr. Wiseman has gone to the trouble of computing his Figs. 1, 2 and 3 and Table VIII to compare the Harrison-Anderson procedure once again with the interflection computations. Perhaps he may be able to substitute comparisons with the zonal-interflectance method. The Lighting Design Practice Committee has for the past three years considered this as a recommended method.

Dr. Spencer has emphasized on a number of occasions that $k_r$ values become less reliable as the rooms approach the high, narrow form. If this is a factor in the agreement between measured and calculated data, it would be interesting to know whether the correction factors could be qualified as to room shape — is the overall agreement better in the larger rooms?

The first four lines of Table II confirm the fact that the interflection treatment of the ceiling component is a "natural" for highly diffusing transilluminated ceilings. But it is all too easy to jump to the conclusion that, because an indirectly-lighted ceiling is a diffusing source at the ceiling plane, it is equivalent to a luminous ceiling. If ceiling brightness extends quite uniformly right up to the walls, nearly half of the flux around the periphery is intercepted by the walls before reaching the work-plane. With typical good indirect lighting, on the other hand, pools of brightness on the ceiling, relatively remote from the walls, are more effective in producing work-plane illumination. Therefore, we feel that the Potter and Russell data on indirect lighting should not have been included in this table on ceiling components, because it covers a different practical case. These last two correction factors are based on measurements in model rooms with actual indirect luminaires, as related to careful calculations of ceiling and wall components and interflectance factors for the exact rooms. It does not seem right to append this data to that for an entirely different kind of initial flux distribution. Moreover, Potter and Russell recognized that the differences varied with room conditions, and did not consider an average difference to be significant.

In the paper cited as Reference 2, Potter and Russell considered this matter of brightness distribution so important that they computed the effective interflectance factors for this type of indirect lighting. They showed that for typical silvered-bowl installations, a ceiling interflectance factor correction as high as 1.3 may be needed to match the measured value. If trapping of light by the luminaire had been excluded, this figure would have been even higher.

Indirect lighting presents a variety of conflicting factors; let us gather them into a summary.

Luminous ceilings are characterized by a relatively high

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degree of ceiling brightness uniformity. In contrast, indirect lighting produces a brightness pattern so disposed as to result in a somewhat higher utilization, depending on luminaire arrangement and the proportions of the room. Indirect luminaires direct some light toward the upper walls, for which ceiling interflectances do not give an accurate evaluation.

Luminaires with wide upward distribution are approximated by longer suspensions with narrower spread. Greater amounts of light strike the upper walls. Light is directed away from the region above the luminaire, to minimize obstruction by the latter. They produce better ceiling brightness uniformity and improved appearance.

Luminaires with narrow upward distribution, such as typical fluorescent designs, are approximated by very short suspensions of broader types. Ceiling brightness is confined to pools or strips, close to the luminaires. While this disposition of ceiling brightness is favorable in general to good utilization, the luminaire itself will definitely obstruct the ceiling-reflected light flux directed toward the work-plane.

In Reference 2 these trends are well illustrated; in Table VIII, for a large room with luminaires suspended at 14 inches, the computation of Ceiling Ratios indicates that 91.3 per cent of the upward light from the wide distribution strikes the ceiling, and 96.7 per cent for the narrow distribution. Thus the narrow spread starts out with a 6 per cent advantage. However, referring now to Fig. 7, it is shown that, despite the more favorable Ceiling Ratio and brightness disposition from the narrow (approximately cosine) distribution, the measured utilization is but 95 per cent as great as with the wide (bat-wing) distribution. This reversal must be due to the different amounts of light trapped by the luminaires in the two cases, although their bulk was equal for the conditions under discussion; and shows that for indirect lighting, Ceiling Ratios are not by themselves reliable indicators of relative ultimate illuminating effectiveness. To carry this one step further, it is calculated that, *with equal lumens incident on the ceiling*, about 12 per cent less reach the work-plane when they result from a narrow distribution which produces bright areas directly above the luminaires.

The inter-related trends lead us to conclude that a few correction factors applied to the ceiling component interflectance are not enough to provide satisfactory accuracy, even with precise computations of the flux incident on the ceiling and walls. Corrections would be needed applicable to varying conditions of ceiling brightness distribution, luminaire arrangement and suspension, and the degree of openness of the luminaire. These sound too complex. We believe that, despite the desirability of predicting utilization directly from a candlepower curve, there is still an important need for empirical tables of utilization factors. These would take into account the effect of the shape of upward distribution, as well as the inherent trapping introduced by the specific luminaire.

ROBERT S. WISEMAN:* I wish to thank Dr. Spencer, Professor Bull and Mr. Meaker for their comments on this paper. Since the purpose of these calculations was to determine the effects of the component "correction factors" on the total, the experimental data of Churchill and Putnam, which does agree amazingly well with the theory, was not used to determine the factors used because the effect of the largest probable correction factors was of more interest than smaller values.

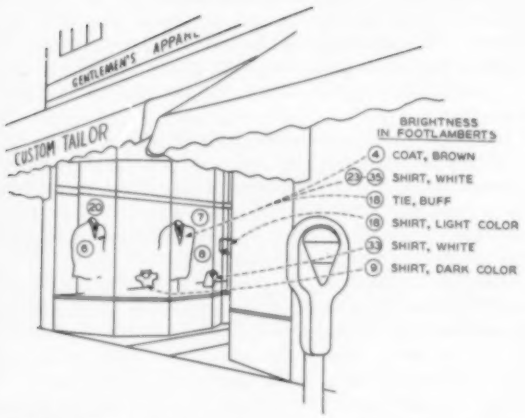
It is interesting to note the close agreement between the experimental data obtained by Bull and the data I reported two years ago. Since our data is in such good agreement and since I was able to repeat data, it is doubtful that the uncertainties of these data are as great as Dr. Spencer would have one believe. Again let me point out that the theoretical data were obtained by making certain basic assumptions which are not quite true, and the integral equations could only be solved by using an approximation. It should not be expected that the theoretical and experimental data should agree.

As Mr. Meaker indicates, if these experimental rooms had not been designed to reproduce the basic assumptions as closely as possible the variations between experimental and theoretical data might be even greater than Professor Bull and I measured. His other comments are also very significant and worthy of consideration by those interested in this problem.

*Author.

**Index to 1956—**
**Officer-Committee Directory**

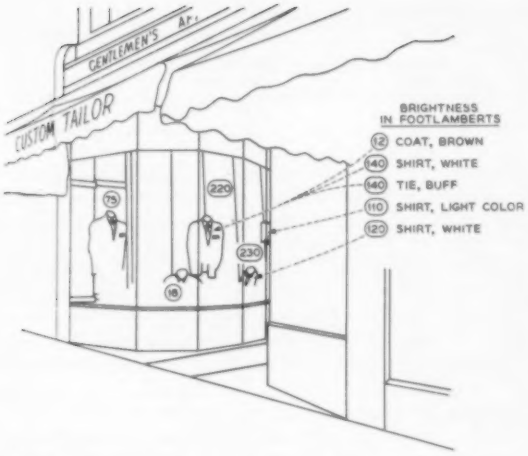
The annual Index to 1956, published as Part II of this issue, this year gives the business addresses, when available, of I.E.S. officers and committee personnel for 1955-1956 and 1956-1957, and so could be used as a Directory of officers and committee members.




**FROM THIS:** **Reflections from the bright street obscure the display of merchandise in the shadowed show window.**

# Re-lighting a Show Window

**BY MEANS OF THIS:** **High-brightness background by luminous panels with spot and floodlights accenting featured articles in the display.**




**TO THIS:** **Merchandise is visible on a similarly bright day. Note reflections in windows of neighboring stores.**

# With Results

milj

SHOW WINDOWS are a merchant's best salesman. They occupy the most valuable space in the store, and surveys have indicated that nearly one-fourth of the customers who enter a store do so as a result of seeing, and being attracted by, a display in a show window.

Stephen Roberts — Custom Tailor has a 15-foot frontage on a main business street, several blocks west of the central shopping area in the city of San Rafael, Calif. Pedestrian traffic in this vicinity would be considered moderate. In the course of completing a re-lighting of some portions of the store interior the owner's attention was directed to the importance of show window lighting. Situated on the north side of the street, the store front is often shaded by awnings to prevent excessive fading of merchandise and glare within the store. Contrast between the darkened window and the bright street and sidewalk areas caused window reflections greatly decreasing the visibility of merchandise in the window display.

A two-fold program was undertaken: first, to re-light the windows to minimize street reflections, and second, the project of evaluating the sales impact of the greater visibility of the merchandise on display.

The original equipment in the window consisted of swiveled reflectors for use with 100-watt inside frosted lamps. To increase the quantity of light on the display, R-40 reflector lamps were placed in several of the units — a total of six R-40's and two 100-watt lamps. Several of the lamps had failed and some of the metal reflectors actually interfered with the beam of the R-40's. Because of the flood nature of the lamps and their direction, merchandise in the window was washed with a low level of non-accented illumination. No one article stood out or served as an attraction point in the window.

### Re-Lighting Plan

It was decided to reduce window reflections by changing the low surrounding brightness areas to high surrounding brightness areas, with accent lighting on feature displays. For these highlights the window border lights and swivel sockets, with metal reflectors removed, were lamped with five PAR-38 spots and five PAR-38 floods. Three of the spots and one flood are concentrated on the brown

**TABLE I — Pedestrian Traffic Data.**

| | Date | Time Started | Time Ended | Time Elapsed (Hours) | Total Traffic | Traffic per Hour | Per Cent Look | Per Cent Stop | Per Cent Effective | Weather |
|---|---|---|---|---|---|---|---|---|---|---|
| BEFORE RE-LIGHTING | 2/10 | 11:15 a.m. | 12:10 p.m. | 0.92 | 285 | 311 | 21 | 7 | 28 | High fog, clearing, warm |
| | 2/10 | 2:25 p.m. | 4:25 p.m. | 2.00 | 719 | 359 | 23 | 5 | 28 | Clear, bright, warm |
| | 2/10 | 7:35 p.m. | 9:15 p.m. | 1.67 | 420 | 252 | 25 | 11 | 36 | Clear, bright, mild |
| | 2/11 | 11:12 a.m. | 12:20 p.m. | 1.13 | 398 | 351 | 18 | 5 | 23 | Clear, bright, warm |
| | 2/11 | 3:00 p.m. | 4:15 p.m. | 1.25 | 512 | 410 | 23 | 8 | 31 | Clear, bright, warm |
| | Averages | | | | | 337 | 22 | 7 | 29 | |
| AFTER RE-LIGHTING | 2/17 | 11:30 a.m. | 12:30 p.m. | 1.00 | 330 | 330 | 43 | 7 | 50 | Overcast, light drizzle, mild |
| | 2/17 | 3:00 p.m. | 4:30 p.m. | 1.50 | 408 | 272 | 42 | 8 | 50 | Partly cloudy, cool |
| | 2/17 | 7:45 p.m. | 9:00 p.m. | 1.25 | 180 | 144 | 51 | 10 | 61 | Clear, cold |
| | 2/18 | 11:25 a.m. | 12:33 p.m. | 1.13 | 424 | 275 | 43 | 12 | 55 | Clear, bright, mild |
| | 2/18 | 2:21 p.m. | 3:37 p.m. | 1.27 | 559 | 441 | 39 | 10 | 49 | Clear, bright, cool |
| | Averages | | | | | 292 | 44 | 9 | 53 | |

Merchandise changed in test window, 2/6/56.
Luminous background placed in window and front border lights changed, 2/13/56.

suit in the center of the display. One spot and one flood are aimed at the coat in the street end of the window.

The high surrounding brightness of the back wall area was accomplished by means of an eight-foot square of luminous panels. Large area reflector units, each equipped with two 96-inch cool white slimline lamps, are covered with especially-framed panels of figured translucent plastic. The large-area reflector units are through-wired side-by-side, and have a high-reflectance baked white enamel finish. The woven texture of the plastic diffusing panels breaks up the expanse of the background with a pattern which does not detract from the merchandise on display.

### Evaluating Sales Impact

Because illumination levels, brightnesses and absence of reflections cannot in themselves be graphically translated into sales impact, it was decided to establish the passing pedestrian response to the two lighting systems, old and new. Observations made over a period of time from a car parked in front of the store are shown in Table I. A count was made of the number of pedestrians who passed, looked and stopped. The sum of these categories constitutes the foot-traffic in the vicinity — all potential customers.

As a result of the narrow street frontage and the position of the windows a pedestrian walking three miles an hour passes the store in approximately 3½ seconds. To evaluate the effect of the lighting on capturing attention during this short time span the display material in the window and the decorating theme remained as nearly the same as was possible during the count.

The greatest flow of pedestrian traffic occurs on Friday (when stores are open until 9 p.m.) and on Saturdays. Observations were, therefore, made on Friday mornings, afternoons and evenings and on Saturday mornings and afternoons. Although the weather turned cooler during the later portion of the observations, the results are nonetheless indicative of the sales effectiveness of adequate show window lighting. On the average, twice as many people looked at the merchandise in passing and approximately 30 per cent more people stopped to appraise the merchandise with the new lighting system.

This application and proof of the principle that show windows can be a merchant's best salesman was the first prize winner in the Golden Gate Section's 1956 contest for My Most Interesting Lighting Job. The installation was entered by M. C. Very, Sales Engineer, Fluorescent Fixtures of California, South San Francisco, and Norman Schiewe, A & C Sales Dept., General Electric Co., San Francisco. At the time of this installation, Mr. Schiewe was with the Pacific Gas and Electric Co., San Rafael, Calif.

# Flashing Characteristics of Fluorescent Lamps

**(Discussion of paper by J. H. Campbell and D. D. Kershaw published November 1956 ILLUMINATING ENGINEERING)**

SIGMUND STAWICKI:* The authors of this paper are to be complimented for their investigation which has disclosed some of the reasons for the facts presented in an earlier paper of which I was a co-author with Fred J. Vorlander.

They have utilized the 40-watt rapid-start lamp for their studies. This particular lamp was not available in this country when our paper was presented in 1947. Since the rapid-start lamp is specially designed to be operated with continuously heated cathodes, it lends itself to flashing circuits.

I am gratified that the new data concerning the need for optimum cathode current, and the injurious effects to lamps in flashing circuits if proper cathode heating is not maintained substantiate the data shown in the Vorlander-Stawicki paper. The conclusions drawn are strikingly similar. It would be interesting to know whether the authors noted the beginning of ionization in the vicinity of the cathode at optimum heating.

The information showing the reasons for the failure of flashing circuits to improve lumen maintenance is most informative.

The earlier paper described the application of other sizes of lamps to flashing circuits. Have the authors of this paper any data on other than 40-watt rapid-start lamps?

I feel that flashing fluorescent circuits have not been generally accepted commercially. Perhaps this presentation will stimulate such applications.

J. W. STRANGE:** I feel at a bit of a loss in discussing this paper because my only contact with this subject has been on a rather crude and simple basis and certainly not in the elegant class of the experiments we have been shown. I would like to start by paying tribute to the way the experiments have been conducted and the most interesting film we have seen.

I feel, in fact, that the authors should be encouraged to persist with this work, because at least in one field of activity there is a tremendous opportunity. I think in this country, as well as in England, you have a major problem in radio interference and the figures given (Fig. 1 in particular) indicate that some light might be shown on that phenomenon by a detailed examination of the starting phenomena which have been shown up by the work of this paper.

I wish to encourage the authors, if they have not already started on that work, to apply some of the very interesting techniques which they developed for this paper to that fresh field.

Now, as I say, on the main subject I am not in a position to give much additional information. I was thrown into this aspect of flashing in a rather summary sort of fashion, quite a few years ago, just after the war, when one of our users took some of our lamps and put them on an ordinary circuit and flashed it repeatedly and complained bitterly after two days that lamps were showing signs of wearing out. We were thrown into the job of getting him out of his trouble; and we got out of it fairly simply, by taking the flasher out of the main circuit and putting it in the cathode circuit: in other words, putting the flasher in place of the starter switch, so that when the flasher was closed, the cathodes were heated and when it was opened the lamp lit.

That was the first stage, which was fairly effective. But we got overheating of the cathodes and so we went one stage better and put a resistance in the same circuit to reduce the cathode heating and we put a capacitor across the switch. The result was a very reliable circuit, which did good service.

The main circuit, sometimes modified by using transformer heating of the cathodes fully supports what the authors have said. On standard lamps, we have had something in the order of twenty million flashes without any difficulty. Standard lamps on such circuits give very nearly the same characteristics as lamps on normal circuits.

Reference is made by the authors to Vorlander's paper of 1947. We disagree with him for the same reasons. He was rather too restrictive in his limitations. Flashing is perfectly satisfactory if two conditions are met: the cathodes must not be underheated or you get inadequate electron emission and excessive bombardment; they must not be overheated or the free barium is distilled off.

Now within those two limits you can do almost anything with a fluorescent lamp without damaging it. It is essentially straightforward and simple, and we, in fact, have done the bulk of our work on standard fluorescent lamps. The rapid-start lamps have one advantage. The volt drop across the cathodes is such that it will not promote ionization. We in practice do not have that trouble with standard lamps, but if conditions are not carefully controlled you can get ionization and some shortening of lamp life.

I will finish by thanking the authors for an excellent paper, well presented, and hope they will continue with their work on the fundamentals of cathode design, particularly in relation to radio interference.

J. H. CAMPBELL and D. D. KERSHAW:* We wish again to acknowledge the work of Messrs. Vorlander and Stawicki for their earlier investigation of methods for flashing fluorescent lamps.

The present flashing system is an outgrowth of the circuit and ballast designed for dimming fluorescent lamps in which lamp electrodes are continuously heated to prevent excessive loss of emission material when the arc current is low. Introduction of rapid-start lamps allowed the use of smaller preheat windings and therefore a lower cost dimming or flashing ballast.

Contrary to the test reports of the Vorlander-Stawicki paper, we found it desirable to keep preheat voltage well below the point of ionization. This prevents possible damage to the ballast preheat windings when lamps are deactivated. At voltages required for ionization, an arc may develop across the leads causing excessively high current.

Flashing ballasts have been designed for 24-, 36-, 48-, 64-, 72- and 96-inch T-12 rapid-start lamps. Current ratings

*Champion Lamp Works, Lynn, Mass.
**Thorn Electrical Industries, High Gate, England.

*Authors, General Electric Co., Cleveland, Ohio.

depending on lamp type are 430-ma, 800-ma and 1.0 ampere.

Even at this early date several thousand fluorescent lamp signs employing the flashing circuits are in use and general acceptance of the system appears to be even better than anticipated.

The authors wish to thank Dr. Strange for his kind remarks in connection with our work on flashing of fluorescent lamps.

Tests are continuing and, at this writing, we are pleased to report that Test No. 4 of Table I has now reached 41,000,000 flashes with no failures. The actual burning time is now 5,700 hours.

# The Efficiency of Electroluminescence

## (Discussion of paper by Willi Lehmann published October 1956 ILLUMINATING ENGINEERING)

JOHN F. WAYMOUTH:* I believe Mr. Lehmann has presented very interesting data illustrating the qualitative dependence of efficiency of electroluminescent phosphors on various factors. In any area of science where detailed theories and mechanisms are not yet established, work which leads to uncovering so-called "universal" relationships obeyed by a large variety of samples is quite interesting.

However, I would like to take exception to the method by which Mr. Lehmann measured the power consumption of his cells, and therefore to the absolute values of efficiencies which he has quoted. His equation (1) is correct only when $\cos\phi$ has the following definition:

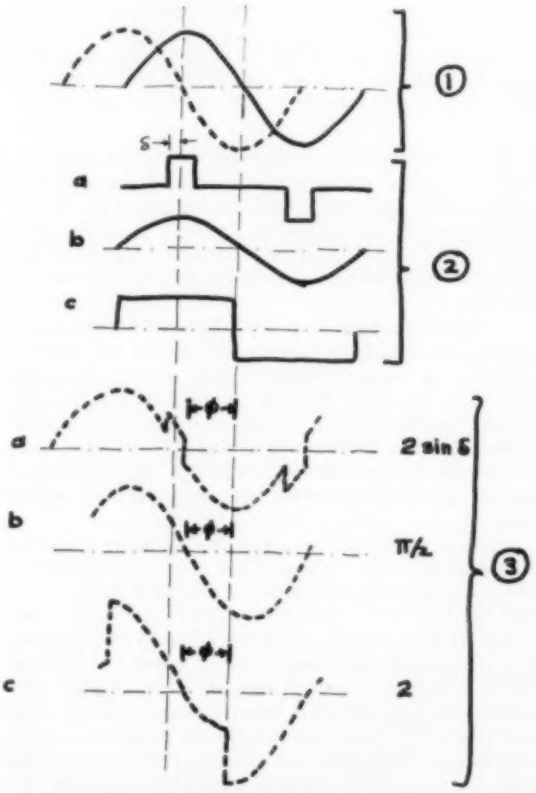
$$\cos\phi = \frac{W}{V \times I}$$

that is to say when $\cos\phi$ = watts divided by volts times amps. Now Mr. Lehmann used an Advance electronic phase angle meter to measure $\cos\phi$. This is an admirable instrument, but it measures not $W/V \times I$, but rather the phase angle between *zeros* on the time axis of the current and voltage waveforms. If and only if the current and voltage waveforms *are sinusoidal*, the power factor computed from this phase angle is equal to $W/V \times I$.

Jerome and Gungle[1] have shown and Lehmann (his Reference 8) agrees that the effective power factor is a function of voltage, increasing with increasing voltage. This means that the cell has a non-linear response, and strongly suggests that the in-phase component of current is non-sinusoidal. If the power factor is small, it will be difficult to detect this by a simple oscilloscope presentation of the total current waveform, since it will be masked out by a large out-of-phase capacitive component which is usually quite sinusoidal.

The accompanying sketches show in a greatly exaggerated fashion: (1) lamp voltage, and out-of-phase component of current; (2) three possible in-phase current waveforms having the same peak value; (3) the resultant current wave shapes in the three cases. Note that the three would all give the same reading of phase angle between voltage and current zeros, and hence the same measured phase angle with the Advance phase angle meter. They would therefore apparently have the same power consumption according to equation (1) of Lehmann's paper.

The actual power consumption can be determined simply by integration of the product of $V \times I$, and is in the ratio




**(1) lamp voltage and out-of-phase component of current; (2) three possible in-phase current waveforms having the same peak value; (3) the resultant current wave shapes in the three cases.**

*Sylvania Electric Products Inc., Salem, Mass.

of 2 sin $\delta$, $\pi/2$, 2. If $\delta \approx 30°$, then this is in the ratio of $1:\pi/2:2$. While the three cases chosen are extreme, they serve to show that substantial errors are inherent in this method of measuring power consumption unless there is strong evidence that the in-phase as well as the out-of-phase components of current are sinusoidal.

We would like to congratulate Mr. Lehmann and the group associated with him for a very vivid demonstration of the use of high frequency power to obtain high brightness from electroluminescent lamps.

1. Jerome, C. W. and Gungle, W. C.: *Journal of the Electrochemical Society, 100,* 34 (1953).

E. E. LOEBNER:* Mr. Lehmann's contribution to the subject of the efficiency of electroluminophors is a significant one. He finds a new and interesting relationship between electric and photic characteristics of certain castor oil embedded zinc sulphide electroluminescence. However, his conclusions cannot be accepted without reservation. It seems necessary to examine some of the assumptions made in a previous publication[1] and referred to in the paper.

Mr. Lehmann assumes that the alternating current which flows through the continuous phosphor particle bridges spanning the capacitor electrodes is a sinusoidal one. This is contrary to my experiment, reported a year ago at the Brooklyn Symposium, and also those described three years ago by Zalm, Diemer and Khasens[2] who employed an electroluminescence capacitor construction similar to that of Mr. Lehmann. The relevance of Lehmann's experimental technique and the applicability of his calculations of the dielectric loss factor, $k$, depend on the unlikely presence of sinusoidal current. Further data are needed to clarify this question.

In addition, it should be kept in mind that even if the presence of sinusoidal current is substantiated, additional proof of direct interparticle contact is needed before Lehmann's physical model can be applied to the particular case investigated.

In any event these potentially very important results have, at the present time, only a limited applicability. It seems necessary first to resolve the discrepancies between the voltage dependence of the dielectric loss factor found by Mr. Lehmann and that reported by Roberts.[3] Also the less reproducible behavior of electroluminescence capacitors using the castor oil embedment indicates the desirability of verification of the new results in other embedding materials.

1. Lehmann, W.: *Journal of the Electrochemical Society, 103,* 24 (1956).
2. Zalm, Diemer, B., Khasens, H. A.: *Philip Res. Rip.*, Vol. 9, p. 81 (1954).
3. Roberts, S.: *Journal of the Optical Society of America,* Vol. 42, p. 850 (1952).

J. O. AICHER:** Do the efficiency values shown in Fig. 5 apply to phosphors only or to entire cells?

Is efficiency usually calculated, according to the equations given, or is wattage consumption commonly measured in making a comparison of several phosphor samples? How is wattage consumption measured in evaluating cell performance?

Lumen maintenance obviously is of vital importance in determining efficiency throughout life. Approximately what percentage of initial lumen output still is obtained from cells having a rated brightness of, say, 100 footlamberts, at 1000 hours of operation?

*R.C.A. Laboratories, Princeton, N. J.
**Large Lamp Dept., General Electric Co., Cleveland, Ohio.

WILLI LEHMANN:* In reply to Dr. Loebner and Dr. Waymouth I would like to state that the evidence of a sinusoidal current through the cell had not been assumed for an exciting sinusoidal voltage. Actually the current always deviates somewhat, although usually very little, from the sinusoidal shape. The objection against the use of the Advance electronics phase angle meter, therefore, is right, at least in principle. We had to take special care that the phase angle readings obtained were in sufficient agreement with the phase angle between voltage and the first harmonic of the current (all higher harmonics of the current do not contribute to a wattage absorption). In practically all cases, this agreement is good enough that the wattage measurements obtained with the phase angle meter are, although not quite correct, a good approximation to the really absorbed wattage. Additionally, some wattage readings have been taken also by an integrating wattmeter and these results are also in good agreement with those obtained with the phase angle meter. Further experiments on this point are in progress.

The discrepancy between the behavior of the dielectric loss factor and Robert's measurements has been solved in the meantime. Our phosphors were measured in the dark while Robert's, probably, were measured in room illumination. I refer to Ince and Oatley, *Phil. Mag. 46,* 1081 (1955).

The use of embedding materials other than castor oil has been tried, including solids. The results are, within the limit of accuracy of the measurements, identical in all cases.

Dr. Waymouth's limitation of the definition of the phase angle, $\cos\phi = W/(VI)$, to sinusoidal waves only seems to be too strong. The same definition and the same strong relationship to the absorbed wattage hold also for any other wave shape if only voltage and current have similar shapes (*i.e.*, both rectangular).

Answering Dr. Aicher, the efficiency data in Fig. 5 apply to the phosphor only. The efficiency of a complete cell is always lower but may be up to 8-9 lumens/watt under the best conditions. Usually all efficiency values have been calculated rather than by comparison from phosphor to phosphor. The wattage absorption of the phosphor only can, with some minor corrections, be obtained by difference measurements of a cell containing phosphor and an empty cell. Detailed measurements of the lumen maintenance of high-intensity electroluminescence have not yet been made.

*Author, Westinghouse Electric Corp., Bloomfield, N. J.

See "Lighting Progress — 1955-1956" beginning on page 1 of this issue.

# New Developments in Short Arc Lamps

## (Discussion of paper by Theodore C. Retzer and G. W. Gerung published November 1956 ILLUMINATING ENGINEERING)

H. M. BAXTER:* It is evident that these new short arc lamps described by the authors will fill the long-felt need for light sources to replace carbon arcs for searchlight applications. For many years there has been a basic demand for lamps such as these for general commercial and military use. The use of searchlights to produce "sky beams" for advertising has become quite widespread, but most of these seen up until now have been 60-inch anti-aircraft carbon arc searchlights from World War II surplus stocks.

We are using the 1000-watt mercury lamp in 18-inch searchlights and the 2500-watt mercury lamp in 36-inch size searchlights for commercial applications and the performance of these has been very promising.

Our principal comment consists of a few questions relative to future possible changes in these lamps. We note that, although the 2500-watt mercury lamp may be operated in any burning position, the 1000-watt size must preferably be burned vertical. We are wondering why the 1000-watt size cannot be operated in any position also. If this particular lamp cannot be operated in any position, possibly a new similar lamp can be made which does operate in any position.

The beam candlepower of a searchlight is directly proportional to the brightness of the lamp arc. We would like to ask if there is any promise of brighter arcs than shown in Fig. 5 of the paper.

The cost of these lamps might seem somewhat high to some prospective users and we are wondering if there would be a possibility of a decrease in these prices with an increased use and production.

THEODORE PROJECTOR:** I was very much interested in the details given by the authors in this paper and am glad to see that since the last presentation and details they have done so much to improve the lamp technically, to extend its life and to make it much more reliable. I am glad to see that all this is being done, and I hope in the future the lamp will offer possibilities of further replacing the carbon arc.

We have certain advantages in the carbon arc, in spite of all its disadvantages, that still commend it to many of our applications where the highest brightness is required and in one application that we have, which is a very important one, where instantaneous light is required and instantaneous light of high intensity.

Even though by the addition of xenon and by the platernizing process they have managed to shorten considerably the heating time, nevertheless, it is far from instantaneous and in one application we have, by the end of thirty seconds the use of the light is finished. This would obviously not permit the use of a mercury-xenon compact arc lamp. However, there are many other places where freedom from the troubles of mechanisms with a carbon arc and the clean operation of this kind of lamp are so advantageous that one might sacrifice the high brightness of a carbon arc and use these lamps. I therefore expect there will be many more applications of it in the future.

THEODORE C. RETZER and GEORGE W. GERUNG:* In answer to Mr. Baxter's first question, the 1000-watt short arc mercury and mercury-xenon lamps are designed for vertical operation. However, the lamp can be operated momentarily in any position, but prolonged operation at an angle exceeding 10 degrees from the vertical will seriously shorten lamp life. With horizontal operation, the larger physical dimensions of the 2500-watt lamp permit the arc and arc-tail flame to be further from the bulb wall and have less effect on devitrification of the quartz bulb than the smaller 1000-watt bulb. In general, best performance will be obtained from all short arc lamps with vertical operation, which results in quicker warm-up and less devitrification of the quartz bulb, resulting in longer lamp life. Rated lamp life applies only when the lamp is operated vertically.

With regard to Mr. Baxter's second question, the arc brightness of short arc lamps can be somewhat increased by reducing arc length. However, the lamps described in the paper were designed for specific applications, and the lamp characteristics were established to meet the requirements of these applications.

In answer to Mr. Baxter's last question, all short arc lamps appear to have a high cost, but at present the lamp operating cost is only 50¢ to $1.00 per hour. Because of the high basic material costs, it is not expected that short arc lamp list prices will be reduced in the immediate future. However, present engineering developments indicate that further improvements in lamp life are possible, which will further reduce relative lamp operating cost.

Mr. Projector's comments point out the fact that the short arc lamps should not be compared with high-powered carbon arcs of 150-200 amperes because of the extreme differences in power input to the two sources. However, the short arc lamps do compare favorably in brightness and efficiency for the same power consumption.

It is a fact that short arc lamps do not produce full output immediately, but it is possible to greatly improve the warm-up of short arc lamps to practically full output by using an auxiliary heater to vaporize the mercury in the lamp bulb before it is turned on.

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**National Bureau of Standards, Washington, D. C.

*Authors, Westinghouse Electric Corp., Bloomfield, N. J.

# LIGHTING NEWS

## W. F. Little Retires as President of E.T.L.

All branches of the electrical industry banded together December 11 to pay tribute to William F. Little, retiring President of Electrical Testing Laboratories, Inc., New York. A reception and banquet was held at the Hotel Lexington, attended by some 90 people, many of whom came long distances for the express purpose of honoring him. Hundreds of others who were unable to be there, sent letters expressing their good wishes, affection and respect, all of which were bound in a beautiful leather book engraved in gold, commemorating the occasion. Those attending the banquet, as well as the numerous letters, represented virtually every phase of the industry — including ballast manufacturers, portable lamps, fixture manufacturers, lamp manufacturers, automotive, highway lighting, scientists, photometric people — to name a few.

Toastmaster for the evening was Dr. Ward Harrison, Consulting Engineer, and a past president of I.E.S. Speakers who paid tribute to Mr. Little, and recapped his long life in the industry included M. N. Waterman, President of I.E.S.; Don Blanchard representing the Society of Automotive Engineers and the American Association of Motor Vehicles Administrators; Hoyt P. Steele, President, Reflector and Lighting Equipment Manufacturers Institute; and E. D. Stryker, speaking for Don Julian of Fleurolier.

Mr. Little was awarded a certificate making him a member emeritus of the New York Section of Illuminating Engineering Society, the presentation being made by G. G. Rae, Chairman of the New York Section. It was noted during this presentation that Mr. Little, together with his wife, had attended without exception every Convention and National Technical Conference of the Illuminating Engineering Society since 1909, and of course, almost every meeting of the New York Section of I.E.S.

Mr. Little was also presented with a handsome nautical clock as a gift from his friends and associates. The nature of this gift reflected Mr. Little's hobby — sailing in Connecticut Sound.

Mr. Little's retirement, which took effect December 31, 1956, comes after nearly 50 years of service. He joined Electrical Testing Laboratories in 1903 and has been with the company ever since, with the exception of a four-year period from 1906 to 1910 when he served as Manager of the Victor Instrument Company. Mr. Little was elected to the Presidency of ETL in 1953 upon the retirement of F. Malcolm Farmer.

Throughout his entire career, Mr. Little was a most valuable member of I.E.S. His work, both for I.E.S. and for the Industry he served has brought him every honor and award given in these fields. He is, of course, a Fellow of I.E.S., and in 1950 was awarded the I.E.S. Gold Medal (highest honor in the field of illumination). He was elected President of the Society in 1930-1931, and served continuously on the Council of I.E.S. for some fourteen years. Mr. Little is a member and Fellow also of the Society of Motion Picture and Television Engineers, and a member of the American Optical Society, Society of Automotive Engineers, a charter member of Inter-Society Color Council, and has served on several committees of the American Society for Testing Materials, American Standards Association and International Commission on Illumination in which he is one of the U. S. representatives on the Committee on Automotive Lighting. Mr. Little was a co-editor of the chapter on Illumination in the *Standard Handbook for Electrical Engineers* (Edition 7 and 8). He has been granted more than a dozen patents.

**TOASTMASTER for the evening banquet honoring W. F. Little, was Ward Harrison, a Past-President of I.E.S.**

**NAUTICAL clock is presented to Mr. Little by Hoffman S. Beagle (left), ETL Executive Vice-President.**

**INDUSTRY honors W. F. Little on his retirement from ETL at banquet held December 11, in New York City.**

W. F. Little's long and valuable career began in 1903 with his graduation from Rutgers University. He became associated immediately with the Lamp Testing Bureau, which later became the Electrical Testing Laboratories, and was one of the original incorporators. He became a director of ETL, Inc., when it was organized in 1942.

Mr. Little's first duties with the original Lamp Testing Bureau were concerned with general testing in the electrical laboratory, and included photometric work. In 1910, following his return to the organization, he became supervisor of all photometric testing, including design of apparatus, calibration of standard lamps, and testing of lighting equipment such as fixtures, luminaires, street lights and illumination test indoor and out. In addition, he supervised spectroscopy and radiometry test activities.

By 1919 automobile headlighting began to receive prominent attention and he organized and participated in much of the pioneer work and testing leading to the preparation of standard specifications for automotive lighting equipment acceptance. These specifications were adopted by a number of individual States.

In World War I he was loaned to the Thomas A. Edison party where he was associated directly with Mr. Edison in the study of camouflage, where brightness measurements of sky, water surface and underwater were required. This work was carried out on Long Island Sound and in Key West, Florida.

During World War II his services were placed at the disposal of a group from Fort Belvoir (Army Engineer Corps) headed by Captain Oscar P. Cleaver. This study covered blackout tests and requirements, and was carried out at Point Pleasant, N. J. and Jacksonville Beach, Florida.

In his address acknowledging the tribute to him, Mr. Little indicated that his retirement will not bring to an end his lifetime interest and participation in I.E.S. affairs. This, to the many who were affectionately honoring him, was good news.

## Anniversary Conference Highlights Recorded on LP

As a final touch which insures the permanence of the record, highlights of the Golden Anniversary Conference of I.E.S., held in Boston last September, were recorded on Edison Voicewriter dictating equipment. This has been edited by Past-President Charles H. Goddard, of Thomas A. Edison Inc., and presented with the compliments of his company to all who attended the Conference.

The twelve-inch double-faced long play disc covers a total of 52 minutes of highlights from the sessions.

Anyone who attended the Boston Conference and has not received this record should get in touch with Mr. Goddard, at the Thomas A. Edison Co., Inc., 51 Lakeside Ave., West Orange, N. J.

## Occupational Vision Conference Sponsored by San Diego Groups

A full-day conference on occupational vision with the theme, "Saving Dollars Through Vision," was sponsored December 12 by the San Diego Chapter of I.E.S., the San Diego County Optometric Society and the Federal Safety Council. The program and speakers were as follows:

Welcome and Introduction of Speakers — Marvin W. Hall, Safety Superintendent, U. S. Naval Air Station, North Island.

Keynote Address — Gordon H. Kindy, O.D., President, California Optometric Association.

As I See It — Donald W. Conover, Ph.D., Human Engineering Group, Convair, General Dynamics.

Color Conditioning — Jack Graham, District Field Manager, E. I. DuPont Corp.

The Visual Efficiency and Safety Program — W. R. Randall, Occupational Vision Representative, Bausch & Lomb Optical Co.

Luncheon — Federal Safety Council December Meeting.

Better Eyes for the Job — Harry C. Jolliffee, O. D., Associate Professor, Occupational Vision, Los Angeles College of Optometry.

Visual Environment for Comfort and Efficiency — Foster K. Sampson, Electrical and Illuminating Engineering Consultant, Los Angeles.

It Pays To See — Robert M. Griffin, Ph.D., Reading Improvement Laboratory, San Diego City Schools.

I.E.S. members on the Conference Committee were C. J. Bunce, Carlton M. Thompson, Gordon Kimball, S. V. Monsees, J. Walter Howard and C. C. Clardy. The San Diego County Optometric Society was represented by W. L. Nelson, Harry W. Whelply, Jr., Gerald Easton, and Warren Krena, Chairman of the Committee. Federal Safety Council members were Marvin W. Hall, Joseph T. Walthall, Lt. Comdr. Bernard G. Platt and Lt. Frank A. Ervin.

## Highway Lighting — Subject of Three-Day Course in Albany

The Eastern New York Section of I.E.S. in cooperation with the Niagara Mohawk Power Corp. sponsored a three-day course in Street and Highway Lighting, last November 14 through 16. C. E. Waldron, Regional Vice-President of the I.E.S. Northeastern Region, acting as State Lighting Engineer of Niagara Mohawk, made the arrangements for the classes, which were held for highway engineers, traffic engineers, public safety officials and other governmental and municipal officials.

The program was outlined as follows:

**Wednesday, November 14**

Fundamental aspects of roadway lighting.
Night visibility problems.
Light and vision.
Illumination terms and definitions.
American Standard Practice for Street and Highway Lighting.

**Thursday, November 15**

Light sources — incandescent, mercury, fluorescent.
Light control — optical systems used for roadway lighting.
Lighting design problems and solutions.

**Friday, November 16**

Street lighting luminaires and application of principles.

As an educational program, no registration or course fee was required. Classes were held at the Niagara Mohawk Auditorium, 126 State St., and began at 9:00 a.m. each day.

## Scale-Model Community Displayed At Home Builders Convention

A community of 23 different scale model homes is being displayed at the National Association of Home Builders Convention in Chicago, January 20-24, under the auspices of the magazine *Living for Young Homemakers.*

Christened "Electri-Living Town, U.S.A." the exhibit includes scale models of homes designed by 23 different architects and built in 22 different regions of the country, in a program co-sponsored by the magazine and utility companies.

# U. S. Representatives Appointed For C.I.E. Technical Activities

For the 1955-1959 quadrennium the International Commission on Illumination (C.I.E.) has appointed sixteen Working Parties to deal with the currently more active technical subjects of international interest. The Parties are made up of from three to eight Experts, each representing one of the National Committees, plus Correspondents from other member countries. They arrange such meetings as may be required to further their projects and are empowered to issue reports between sessions of the Commission. These become official documents upon approval by the C.I.E. Executive Committee which is composed of representatives from each National Committee.

The United States is the only country with Experts on all the Parties. Of these three serve as Chairman.

In addition to the Working Parties there are thirteen Reporting Secretariats, which gather information from the member countries and present progress at the quadrennial sessions.

The United States National Committee is broadly representative of activities related to the science and art of lighting. Its 70 members include representatives of the eight constituent organizations:

Illuminating Engineering Society
American Institute of Electrical Engineers
American Physical Society
Optical Society of America
Society of Automotive Engineers
Society of Motion Picture and Television Engineers
Association of Edison Illuminating Companies
National Bureau of Standards

Also included are other delegates to the last C.I.E. sessions and some members-at-large. The 1956 Annual Meeting convened at State College, Pa., on October 15-16 with 35 members and 21 guests in attendance. The U.S.N.C. President for this year is H. H. Magdsick, and Louis E. Barbrow, National Bureau of Standards, is Secretary.

At the 1955 Meetings in Zurich, this country was ably represented by 37 official delegates and 24 guests. The Proceedings are still available and may be ordered at $15 for the two large volumes from the Treasurer, T. D. Wakefield, Vermilion, Ohio.

The U.S.N.C. welcomes the participation of any who desire wider acquaint-

**U. S. Representation on C.I.E. Working Parties.**

| Working Party | | U. S. Expert | Chairman |
|---|---|---|---|
| W1.1 | — Definitions & Vocabulary | P. Presbrey | H. König, Switzerland |
| W1.3.1 | — Colorimetry | D. B. Judd | D. B. Judd, U. S. A. |
| W1.3.2 | — Color Rendering | D. Nickerson | W. Münch, Germany |
| W1.3.3 | — Color of Signal Lights | F. C. Breckenridge | B. Boorman, Great Britain |
| W1.4.2 | — Visual Performance* | G. A. Fry | H. C. Weston, Great Britain |
| W2.1.2 | — Sources & Measurement of UV & IR | L. J. Buttolph | R. Schulze, Germany |
| W3.1.1.1 | — Predetermination of Illumination and Luminance** | W. M. Potter | J. Dourgnon, France |
| W3.1.1.2 | — Causes of Discomfort in Lighting | S. K. Guth | S. K. Guth, U. S. A. |
| W3.1.1.3 | — Pleasantness in Lighting** | L. S. Harrison | L. C. Kalff, Netherlands |
| W3.2 | — Daylight | J. W. Griffith | R. Cadiergues, France |
| W3.3.1 | — Street Lighting** | D. W. Rowten | J. M. Waldram, Great Britain |
| W3.3.2.1 | — Aviation Ground Lighting | C. A. Douglas | E. S. Calvert, Great Britain |
| W3.3.3 | — Airborne Lighting & Signals* | M. K. Laufer | M. K. Laufer, U. S. A. |
| W3.3.5 | — Automobile Headlights & Signals | V. J. Roper | P. Devaux, France |
| W3.3.7 | — Traffic Signals | A. H. Clarke | K. Grosskurt, Germany |
| W4.1.1 | — Lighting Education in Schools** | E. M. Strong | R. Spieser, Switzerland |

*H. R. Blackwell serves as Secretary of W1.4.2 and P. H. Greenlee as Secretary of W3.3.3.
**The U. S. National Committee has appointed the following as collaborators with its respective Experts on: W3.1.1.1, J. J. Neidhart; W3.1.1.3, H. L. Logan; W3.3.1, C. H. Rex; W4.1.1, W. A. Hedrich.

**U. S. Representation on Reporting Secretariats.**

| Reporting Secretariat | | Assigned to National Committee of | U. S. Representative |
|---|---|---|---|
| S1.2 | — Measurement of Light | Japan | A. E. Krawcek |
| S1.4.1 | — Photopic & Scotopic Vision | Russia | R. P. Teele |
| S2.1.1 | — Sources of Visible Radiation | Sweden | E. H. Salter |
| S3.1.2 | — Home Lighting | Denmark | M. Fahsbender |
| S3.1.3 | — School & Office Lighting | Finland | C. J. Allen |
| S3.1.4 | — Industrial Lighting | Czechoslovakia | W. H. Kahler |
| S3.1.5 | — Mine Lighting | Belgium | E. J. Gleim |
| S3.1.6 | — Lighting of Public Buildings | Italy | J. M. Ketch |
| S3.1.7 | — Lighting for Selling | South Africa | C. M. Cutler |
| S3.1.9.2 | — Lighting for Photography, Cinema & Television Production | Great Britain | H. M. Gurin |
| S3.3.2.2 | — Lighting for Transport, Other Than Automobile or Air | Norway | E. Boghosian |
| S3.3.4 | — Sports Lighting | Brazil | F. D. Wyatt |
| S4.2 | — Legislation, Codes, and Recommended Practices | Israel | W. C. Wagner |

ance with activities pertaining to lighting throughout the world and who wish to contribute to progress through international cooperation.

The next C.I.E. sessions are scheduled to be held over a period of ten days, in June 1959, at Brussels, Belgium.

**DINNER meeting of the Milwaukee Section, I.E.S. was held at the Engineers Society of Milwaukee building. W. S. Fisher, of General Electric Co., was guest speaker with the topic, "Luminous Ceilings." Attendance was 48.**

## Nominations Open for Seven A.S.E.E. Awards

Seven national awards in engineering education will be given by the American Society for Engineering Education at its 1957 annual meeting at Cornell University, June 17-21. Competitions for all awards are now open, and nomination blanks are ready, according to Professor W. Leighton Collins, Secretary of the Society.

The seven awards are:

(1) The Lamme Award, given annually to an engineering educator for distinguished achievements contributing to the advancement of the profession. This is A.S.E.E.'s oldest award and its highest honor.

(2) The George Westinghouse Award, for distinguished contributions to teaching engineering students, which is especially intended to encourage younger men who show superior teaching ability.

(3) The Vincent Bendix Award, a gold medal given annually for top achievement in engineering research in colleges and universities.

(4) The Curtis W. McGraw Research Award to honor young staff members for contributions through engineering college research. This prize, to be given for the first time next year, is to recognize outstanding early research achievements and to encourage the continuance of such activity.

(5) The James H. McGraw Award in Technical Institute Education, presented for established achievement in technical institute education — teaching, administration, publications, and other forms of leadership.

(6) The President's Awards to Young Engineering Teachers, given annually for papers written by young engineering teachers on a phase of engineering education.

(7) The Engineering Drawing Award of a certificate for distinguished service by a member of the A.S.E.E. Engineering Drawing Division.

The awards are given to winners selected, in each case, by special committees assigned to study the records of each nominee. Further information and blanks for nominations are available from Professor W. Leighton Collins, Secretary of A.S.E.E., at the University of Illinois, Urbana, Ill.

**FIRST meeting of the year of the New England Section featured a tour of Blinstrub's Village, one of the largest night clubs in the world, recently equipped with the latest in theatrical lighting. Left to right in photo are: Fred Vorlander, President of Vorlander Lighting who installed the lighting; Rollo Gillespie Williams of Century Lighting, designer of the system; Stanley Blinstrub, owner of the night club; and Raymond Smart of Boston Edison Co. The meeting continued with a tour of Kresge Auditorium, M.I.T., where the lighting was designed by Stanley McCandless, of Century Lighting.**

## "Safe Driving Tips" Compiled By I.E.S. Committee

In keeping with the President's Highway Safety Program, the Motor Vehicle (Exterior) Lighting Committee, Ray P. Teele, Chairman, has again this year compiled a list of "Safe Driving Tips." The first such compilation was made in the fall of 1955.

(*Continued on page* 12A)

"DECIDEDLY BETTER"

DAY-BRITE

*Lighting Fixtures*

DAY-BRITE LIGHTING MAKES THE BIG DIFFERENCE HERE

## Worker morale greatly improved

Two of the chief reasons for office modernization are (1) to improve appearance, and (2) to increase worker efficiency and comfort. Both are accomplished in the highest degree with Day-Brite lighting. Quality-built throughout, Day-Brite fixtures are modern in every respect—designed to enhance office beauty and raise office morale . . . If you are contemplating an original or relighting installation, by all means make a point-by-point comparison between Day-Brite and any other make. Look at the fixtures, not just the pictures. Then make your choice—wisely . . .
*Contact your Day-Brite representative . . . Day-Brite Lighting, Inc., 5432 Bulwer Ave., St. Louis, Mo.*

NATION'S LARGEST MANUFACTURER
OF COMMERCIAL AND INDUSTRIAL
LIGHTING EQUIPMENT

Part of an extensive Day-Brite modernization job in the offices of Genessee Valley Union Trust Company, Rochester, N. Y.
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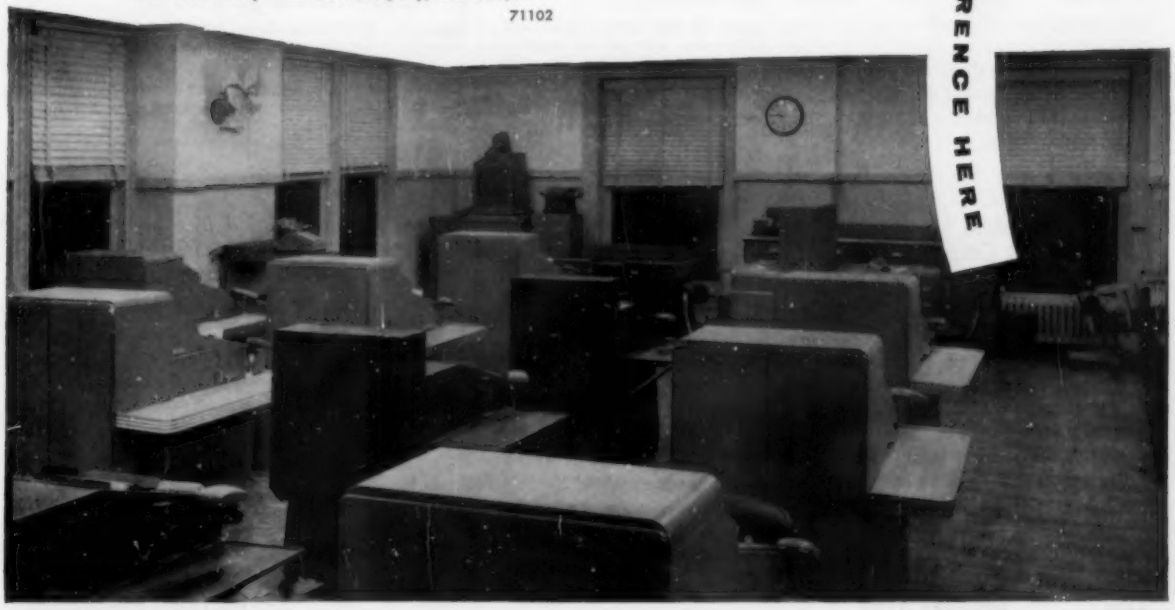


(*Continued from page 10A*)

The sixteen tips are being circulated as part of the drive entitled "Back the Attack on Traffic Accidents," sponsored by the President's Committee for Traffic Safety and 93 other organizations of the Traffic and Transportation Conference of the National Safety Council.

The mimeographed listing can be obtained from the Technical Department, I.E.S. headquarters.

## 1957 "Housepower" Program Outlines Year's Plans

Plans for the 1957 Housepower program have been announced by the Edison Electric Institute Commercial Division, T. O McQuiston, Chairman. Five basic objectives of the program, which has as its long-term goal the modernization of wiring in an estimated 20,000,000 American homes, have been outlined for the coming year. These are to build a wider consumer recognition, to increase trade ally support and enthusiasm, to integrate the Housepower program with other industry programs, to concentrate on accelerating local selling action machinery and to show specific results in more rewired homes.

## Changes in Social Security Effective This Year

Changes made in the social security law by the Social Security Amendments of 1956 apply also to the recently added category of consulting engineers, self-employed architects, etc. Principal effect of the changes include disability benefits and a new retirement age for women. Also changed is the percentage of the tax.

Information on these changes, in detail, can be obtained from the District Offices of the Department of Health, Education and Welfare.

## SCHEDULED EVENTS

**January 16-18, 1957** — Society of Plastics Engineers, Thirteenth Annual Technical Conference, Hotel Sheraton-Jefferson, St. Louis, Mo.

**January 17-18, 1957** — Engineers Joint Council, General Assembly, Statler Hotel, New York, N. Y.

**January 21-25, 1957** — American Institute of Electrical Engineers, Winter General Meeting, Hotel Statler, New York, N. Y.

**January 28-31, 1957** — Plant Maintenance & Engineering Conference, Public Auditorium, Cleveland, Ohio.

**February 14, 1957** — I.E.S. Council Meeting, New York, N. Y.

**February 17-20, 1957** — National Electric Sign Association, Annual Convention and Exhibit, Sheraton Park Hotel, Washington, D. C.

**February 21-22, 1957** — National Adequate Wiring Conference, Sherman Hotel, Chicago, Ill.

**February 25-28, 1957** — American Society of Heating and Air-Conditioning Engineers, 63rd Annual Meeting, Chicago, Ill.

**February 25 - March 1, 1957** — 13th International Heating and Air-Conditioning Exposition, Chicago, Ill.

**March 11-14, 1957** — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

**March 28-29, 1957** — Pacific Northwest Regional Conference, Illuminating Engineering Society, Empress Hotel, Victoria, B. C.

**April 3-5, 1957** — South Pacific Coast Regional Conference, Illuminating Engineering Society, Hotel Statler, Los Angeles, Calif.

**April 8-11, 1957** — Fourth National Electrical Industries Show, 71st Regiment Armory, New York, N. Y.

**April 11-12, 1957** — Inter-Mountain Regional Conference, Illuminating Engineering Society, Alvarado Hotel, Albuquerque, N. M.

**April 18, 1957** — I.E.S. Council Meeting, New York, N. Y.

**April 28-30, 1957** — Southwestern Regional Conference, Illuminating Engineering Society, Holiday Inn, Oklahoma City, Okla.

**April 29 - May 3, 1957** — Society of Motion Picture and Television Engineers, Shoreham Hotel, Washington, D. C.

**April 30 - May 2, 1957** — National Association of Lighting Maintenance Contractors, Conference, Kansas City, Mo.

**May 6-8, 1957** — Air Conditioning and Refrigeration Institute, Annual Meeting, The Homestead, Hot Springs, Va.

**May 9-10, 1957** — Midwestern Regional Conference, Illuminating Engineering Society, Hotel Pfister, Milwaukee, Wis.

**May 13-14, 1957** — Great Lakes Regional Conference, Illuminating Engineering Society, Pantlind Hotel, Grand Rapids, Mich.

**May 16-17, 1957** — Canadian Regional Conference, Illuminating Engineering Society, Hotel Sheraton Brock, Niagara Falls, Ont.

**May 23-24, 1957** — East Central Regional Conference, Illuminating Engineering Society, William Penn Hotel, Pittsburgh, Pa.

**June 4-6, 1957** — Chicago Electrical Industry Show, Conrad Hilton Hotel, Chicago, Ill.

**June 12, 1957** — I.E.S. Council Meeting, New York, N. Y.

**June 13-14, 1957** — Northeastern Regional Conference, Illuminating Engineering Society, Hotel Statler, New York, N. Y.

**June 24-28, 1957** — American Institute of Electrical Engineers, Summer General Meeting, Montreal, Que.

**August 26-30, 1957** — American Institute of Electrical Engineers, Pacific General Meeting, Yakima, Wash.

**September 9-13, 1957** — Illuminating Engineering Society, National Technical Conference, Biltmore Hotel, Atlanta, Ga.

**October 4-9, 1957** — Society of Motion Picture and Television Engineers, Hotel Sheraton, Philadelphia, Pa.

**October 7-11, 1957** — American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

**October 21-25, 1957** — National Safety Council, 45th National Safety Congress & Exposition, Chicago, Ill.

**November 11-15, 1957** — National Electrical Manufacturers Association, Traymore Hotel, Atlantic City, N. J.

**November 18-21, 1957** — 10th Exposition of the Air-Conditioning and Refrigeration Industry, Navy Pier, Chicago, Ill.

## C. L. I. Schedules Annual Winter Courses

The Lighting Fundamentals Course, lecture and laboratory; Wiring Design; and the lecture and laboratory sessions of the Lighting Design Problems Course, sponsored by the Chicago Lighting Institute in cooperation with the Chicago Section of I.E.S. and Illinois Institute of Technology, are again being offered.

Raymond E. Wozniak is Instructor for the fundamentals course, both lecture — 1½-hour sessions Monday evenings from January 7, and laboratory — 2-hour periods every other Wednesday which began on January 9.

Wiring Design No. 1 — 1½-hour classes every Tuesday from January 8 — is under the direction of Frank R. McShane.

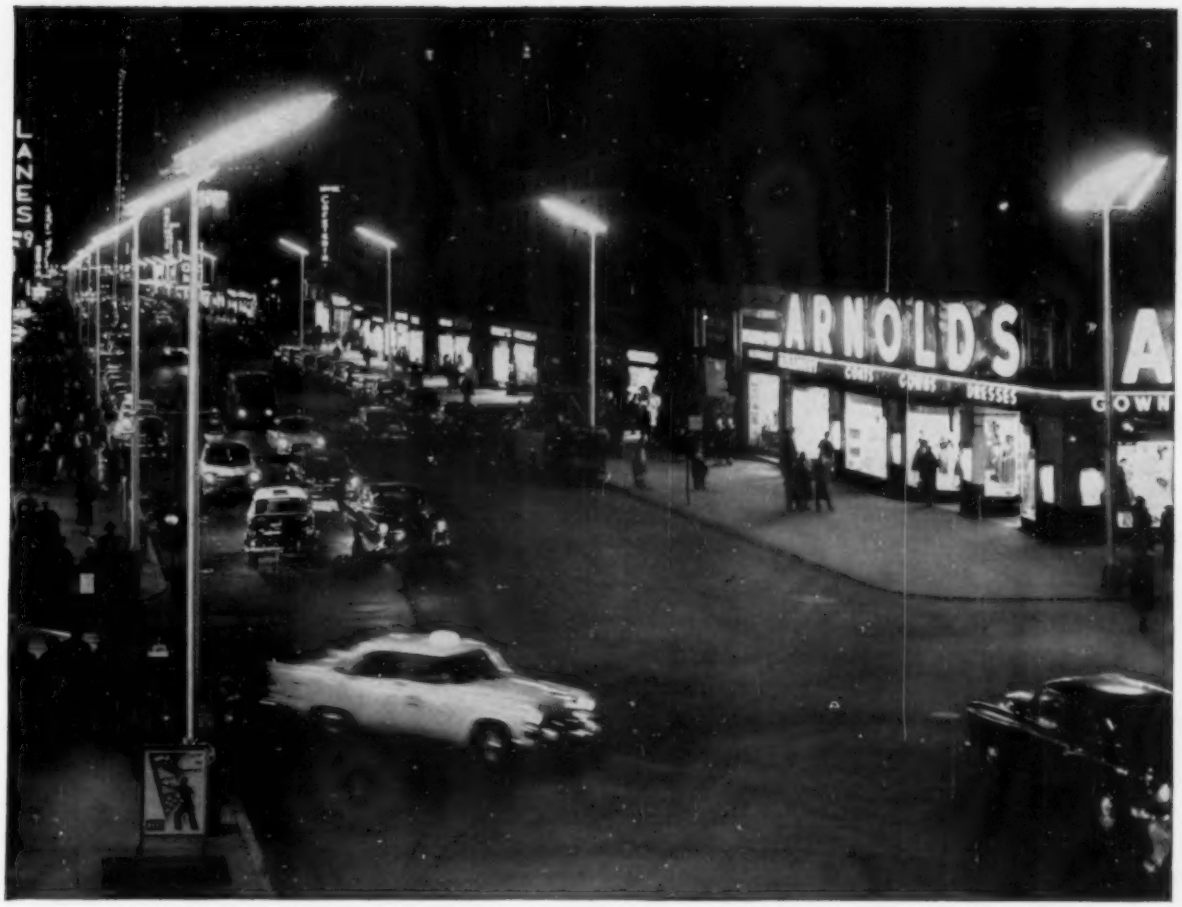
R. R. Lusk is Lecturer for the 1½-hour Thursday sessions of Lighting Design Problems lecture series, which began January 10; and Mr. Wozniak is Instructor for the laboratory section, held every other Wednesday from January 16.

Tuition for each of the three courses is $25. The courses are held at the Institute's quarters in the Marquette Building, 140 South Dearborn St., Chicago.

## Planning Guide Distributed For National Electrical Week

A Planning Guide for National Electrical Week, being observed February 10 through 16, has been distributed by the sponsors of the project to all major segments of the electrical industry in communities throughout the country. The guide contains a description of the "week" — its purpose and objectives, national plans, staging a community program, project ideas, projects for industry groups, literature available for distribu-

(*Continued on page 17A*)




## New York City's "14th Street Association" proves modern whiteway lighting pays big dividends

With the use of P&K aluminum standards and LUXaire® Fluorescent Luminaires, the average light level on 14th Street, a major downtown shopping center, has been increased from 0.4 to better than 2 foot candles. The P&K LUXaire® units, specially designed in wedge shape, are mounted at 30-foot height on 70-foot spacings.

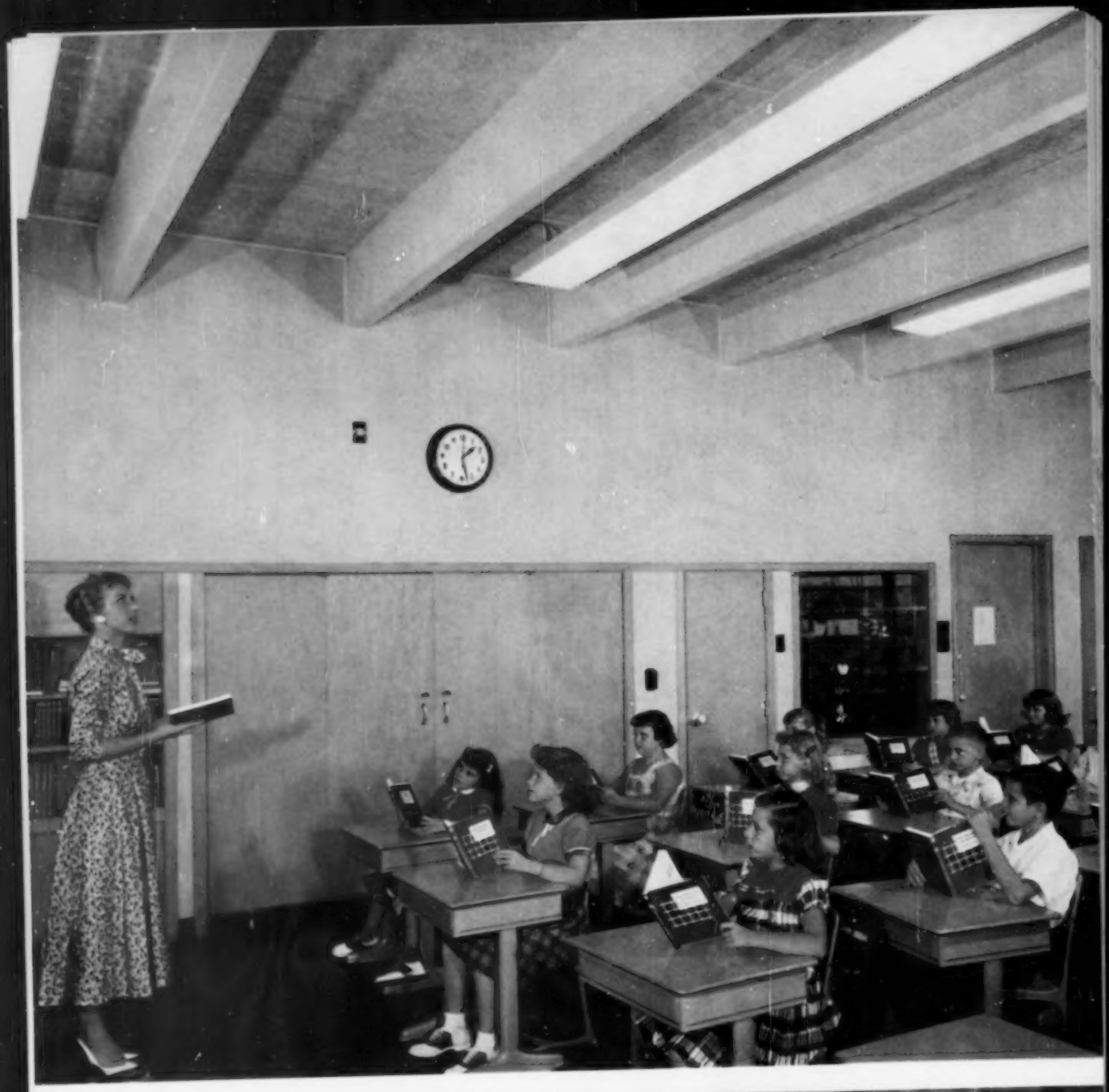
The choice of P&K equipment, combining high strength with light weight, permitted the use of existing electrical vaults with a minimum of excavation and foundation work. Installation was quick, easy, and low in cost. Negligible maintenance requirements, a feature of all P&K products, will serve to keep the *real* cost of lighting equipment on 14th Street surprisingly low.

Comments from the 14TH STREET ASSOCIATION, who paid for the new lighting: "New White way has accomplished its purpose . . . business improvement . . . enhanced shopping area . . . safer for shoppers and vehicular traffic. . . ."

WRITE FOR A COPY OF THE P&K LUXaire® Catalog . . . and use the P&K planning and advisory services without obligation.

**P&K PFAFF & KENDALL**

**84 FOUNDRY ST., NEWARK 5, N. J.**



Fluorescent fixture noise is due to ballast noise, fixture amplification, type of ceiling, etc. G-E ballasts are designed to operate quietly and give you a "Sound Rated" installation every time.

G.E. has designed a three-piece core assembly with push-on clamps. All air gaps are cemented and special coil wedges reduce vibration in the core and coil assembly. A special potting compound aids in noise reduction.

G.E.'s new sound laboratory pays off in quieter ballasts for you. Sound engineers test every new design and spot check production models in an attempt to find new methods and materials to give you a quieter ballast.

*Adequate light, yes—But WHAT'S THAT HUMMING?*

# New General Electric Sound Rating Calculator to aid fixture manufacturers

Many fluorescent lighting installations are furnishing the specified light, but they also are furnishing an unspecified distraction—*noise.*

Every ballast has a normal magnetic hum. However, the intensity of the humming in fixtures is dependent not only upon such factors as basic ballast construction and the ballast rating, but fixture construction and installation can also contribute to a large extent to noise amplification. And, because of these variable factors, fluorescent lighting installations can range all the way from silent to noisy and annoying.

Now specifiers of fluorescent lighting can determine beforehand whether or not they will encounter a ballast noise problem.

It's done this way: every G-E ballast currently listed has a sound rating. By knowing this rating, the number of ballasts in the installation, the size and acoustical characteristics and ambient sound level of the room, they can determine whether or not a sound problem will be encountered. All they have to do is feed this information into the exclusive new G-E ballast Sound Rating Calculator. It's as simple as that.

You'll want to be sure that your fixtures can be "Sound-rated," therefore, use General Electric ballasts and give your customers a sound-rated installation every time.

*Progress Is Our Most Important Product*

GENERAL ELECTRIC

On the spot application engineering assistance is also available. Nearly 100 ballast application engineers located throughout the United States stand ready to assist you. They are as close to you as your telephone.

**SEND FOR YOUR SOUND RATING CALCULATOR**

**Send check for one dollar with your name and address to: General Electric Company, Section A401-30, Schenectady 5, N. Y. Your Sound Rating Calculator will be sent to you by return mail.**

# GARCY

## 5600 Series
## Recessed Luminaire

with one-piece plastic shield

## Weigh it

### against other Large-Area Luminaires

Compare this plastic panel with the shielding on other 4 ft. by 4 ft. fixtures. Where the conventional flat panel sags of its own weight, Garcy's die-formed contour gives lasting stability...permits lighter weight and reduced ceiling load. Installation, cleaning and relamping go more quickly. The panel swings down easily in its hinged frame, puts no strain on the fixture or the worker.

Compare it also for beauty, durability, efficiency. When the fixture is lighted, the contour is hardly noticeable, lending an unobtrusive but interesting "character" to the ceiling treatment. The light is evenly diffused and efficiently transmitted. For the luxury look in lighting, choose Garcy's 5600 Series.

**Available in the following sizes: 4' x 4'; 2' x 2'; 2' x 4'; 2' x 8'. Also available with Alba-Lite glass or louver shields. 1/16" Plexiglas shield in pattern shown is available in matte finish.**

**Send for Bulletin 552-L**

**GARCY** **Quality by *Design***

Garden City Plating & Mfg. Co., 1760 N. Ashland Ave., Chicago 22, Illinois

In Canada: Garcy Co. of Canada, Ltd., 1244 Dufferin Street, Toronto 4

(*Continued from page* 12A)

tion, information for advertising and publicity and pattern speeches.

Chairman of National Electrical Week Committee is Merrill E. Skinner, Union Electric Co. Sponsoring organizations are:

Air-Conditioning and Refrigeration Institute
American Home Laundry Manufacturers Association
American Home Lighting Institute
Edison Electric Institute
International Association of Electrical Leagues
International Association of Electrical Inspectors
International Brotherhood of Electrical Workers
National Appliance and Radio-TV Dealers Association
National Association of Electrical Distributors
National Electrical Contractors Association
National Electrical Manufacturers Association
National Industrial Service Association

## Panhandle to Edmonton — Tradition Is Upheld

The Panhandle Chapter of I.E.S., taking with all due seriousness its obligation to present a gavel to the next youngest Chapter, carried out this tradition of I.E.S. by sending a personal envoy to the Edmonton (Alberta) Chapter, all the way from Amarillo, Texas.

The gavel, with an engraved gold plate of presentation, was entrusted to Joe Russell by then Chairman of the Chapter C. R. McCracken. In addition to the gavel, he carried a copy of the well-known "Texas Brags" map, a deed to a famous oil well, a desktop Texas flag, information on the city of Amarillo and a certificate of honorary citizenship in the empire of Texas, made out for the entire Edmonton Chapter.

Mission was accomplished at the September meeting of the Canadian group, who showed Mr. Russell a brand of hospitality challenging that of his native state.

**GAVEL and other gifts to the Edmonton Chapter, I.E.S. from the Panhandle Chapter are entrusted to Joe Russell (right) by C. R. McCracken, Panhandle Chapter Chairman at the time the presentation was made. Mr. Russell delivered the gavel and gifts in person.**

# ABOUT PEOPLE

The appointment of **Marshall N. Waterman** as commercial engineering manager of the large lamp department of the Westinghouse Lamp Division, Bloomfield, N. J., has been announced. Mr. Waterman, who has been active in lighting for over 25 years, joined Westinghouse in 1948.

The appointment of **S. George Lawson** as operations manager in charge of photoflash and incandescent operations for Sylvania Electric Products Inc. has been announced. In his new post, Mr. Lawson will be responsible for manufacturing operations at the company's incandescent lamp plants in Salem, Mass., and St. Marys, Pa., and the photoflash bulb plants in Montoursville, Pa., and Winchester, Ky. He will make his headquarters in Montoursville.

Day-Brite Lighting, Inc., St. Louis, Mo., anounces the appointment of **Charles L. Amick** to the position of Manager, Sales Department; and **Brooks Chassaing** to the position of Midwestern Regional Sales Manager. Both appointments were effective December 1. Mr. Amick joined Day-Brite in 1955 as Central Regional Sales Manager. Formerly he was with General Electric Co. at Nela Park. Mr. Chassaing comes to his new position from The Art Metal Co., where he was General Sales Manager and exclusive Sales Representative in the Midwestern Territory.

**James F. Davenport,** vice-president and general manager of Southern California Edison Co., was elected executive vice-president of the company. Mr. Davenport had just returned from Geneva, Switzerland, where he was the United States' Delegate to the 1956 session of the Committee on Electric Power, one of the principal subsidiary organs established by the United Nations Economic Commission for Europe.

**Charles T. Nichols** has been named manufacturing manager of the large lamp department of Westinghouse Electric Corp., Lamp Division. Mr. Nichols began his career with Westinghouse in 1928 and since 1953 has been manager of Southern lamp plants.

**Everett S. Lee** has retired after more than 40 years with the General Electric Co., where since 1951 he has been editor of the *General Electric Review*. Mr. Lee is a past-president of the American Institute of Electrical Engineers. Succeeding him as editor of the *G-E Review* is **Paul R. Heinmiller,** who has been managing editor of the publication.

The appointment of **Frederick A. Wolfe, Jr.,** as product sales manager for panelescent lamps of the Lighting Division of Sylvania Electric Products Inc. has been announced. Mr. Wolfe, who has been assigned to various manufacturing sales posts in the development of panelescent lighting during the past four years, will continue to make his headquarters at the company's Salem, Mass., offices.

The following reorganization of J. A. Wilson Lighting & Display Ltd., Toronto, Ont., and J. A. Wilson Lighting & Display Inc., Buffalo, N. Y. has been announced. **J. Carl Wilson** has acquired control of the Canadian company and has become President and General Manager; **Bertram A. Wilson** has acquired control of the American company and becomes

(*Continued on page* 18A)

(*Continued from page* 17A)

President and General Manager; **Harry R. Yates** has been elected a Director and Vice-President in charge of operations for the Canadian company.

The Westinghouse Lamp Division announces the appointment of **Joseph F. Kempf, Jr.,** as midwestern region sales manager. In his new position, Mr. Kempf will direct the sale of all the company's lamp products in ten midwestern states. He will make his headquarters at the Merchandise Mart, Chicago.

**M. K. Fahnestock,** research professor of mechanical engineering and chairman of the Physical Environment Unit of the University of Illinois, has been selected to receive the F. Paul Anderson Medal, highest award of the American Society of Heating and Air-Conditioning Engineers. Presentation will be made at the annual banquet concluding the 63rd Annual Meeting of the Society, February 25-28.

The appointment of **Robert P. Shelly** as Philadelphia district sales manager of the Westinghouse Lamp Division has been announced. Mr. Shelly is making his headquarters at the company's offices at 3001 Walnut St., Philadelphia.

The Holophane Co., Ltd., Canada, have recently opened a new plant and offices at 418 Kipling Ave., South, Toronto. **Frank T. Groome,** president of the Canadian company, was toastmaster at a luncheon at which **Clarence C. Keller,** vice-president of Holophane Co., Inc., New York City and also a director of the Canadian company, was presented with an autographed photo of the new building by **John Harrison,** vice-president in charge of Sales, to be installed in the office of **Charles Franck,** president of the United States company and chairman of the board of its Canadian affiliate.

**CERTIFICATE of recognition for his services as Chairman of the St. Louis Section last year is presented to Ernest W. Stohlmann (standing, left) by this year's Chairman, Robert J. Welch. Seated are C. A. Winkelhake, of Darell Boyd Harmon and Associates, Austin, Texas, featured speaker of the October 25 meeting, and I.E.S. Director Brooks Chassaing.**

**Hugh J. Hanbury** has been named sales manager of the newly created photo lamp department of the Westinghouse Electric Corp. Lamp Division. Mr. Hanbury will have his office at the Division's Bloomfield, N. J., headquarters.

**AUTOGRAPHED photo of new Holophane plant in Toronto is accepted by Clarence C. Keller, left, Vice-President of the company, from John Harrison, Vice-President in Charge of Sales.**

The J. C. Epperson Co. has been appointed sales representative in Northern California and Nevada for the Hexcel Products, Inc., Oakland, Calif. **J. C. Epperson,** electrical engineer, is head of the sales firm, and **Ray Cook** is the illuminating engineer.

**A. A. Berard,** president of Ward Leonard Electric Co., has been elected president of the National Electrical Manufacturers Association, succeeding **J. W. Corey. F. F. Leock,** president of the Allen-Bradley Co., was named association treasurer. Vice-Presidents chosen are: **N. J. MacDonald, J. J. Mullen, Jr., B. C. Neece, W. V. O'Brien** and **J. L. Singleton.**

**Jean Kempner** and **Paul O'Connell,** of Kempner & O'Connell Associates, Inc., Chicago, have been appointed sales representatives to the lighting industry by Merix Chemical Co.

The signing of a license and engineering agreement between Sola Electric Co., Chicago, and "Electromar" Industria Electrica Brasileira S. A., Rio de Janeiro, has been made known. President of the Brazilian firm is **Dr. Arthur Bernardes Filho;** and negotiation of the agreement was made through **Louis E. Walker,** Electromar's U. S. representative. Under the agreement, Electromar is licensed to manufacture electrical equipment utiliz-

(*Continued on page* 23A)

# This NEW Book really talks lighting facts!

It's a MUST for your reference file!

Here's a new Koppers Technical Bulletin of practical do's and tabus for people who make lighting their business. It deals with EVENGLO® polystyrene for use in lighting fixtures . . . and it's yours, *free*. Just fill in the attached coupon.

## You'll find . . .

In this 18-page book you'll find facts you want and need when working with EVENGLO. There are tips on fabrication and forming . . . tables on light-transmission characteristics and typical properties . . . information on special formulations . . . design considerations . . . assembly techniques . . . data on annealing, adhesives and machining . . . plus important facts on optical advantages, light diffusion, permanence and heat resistance of EVENGLO. After your copy arrives, you'll find yourself referring to it for assistance in planning almost every lighting job. Send for your copy today.

## Clip and Mail

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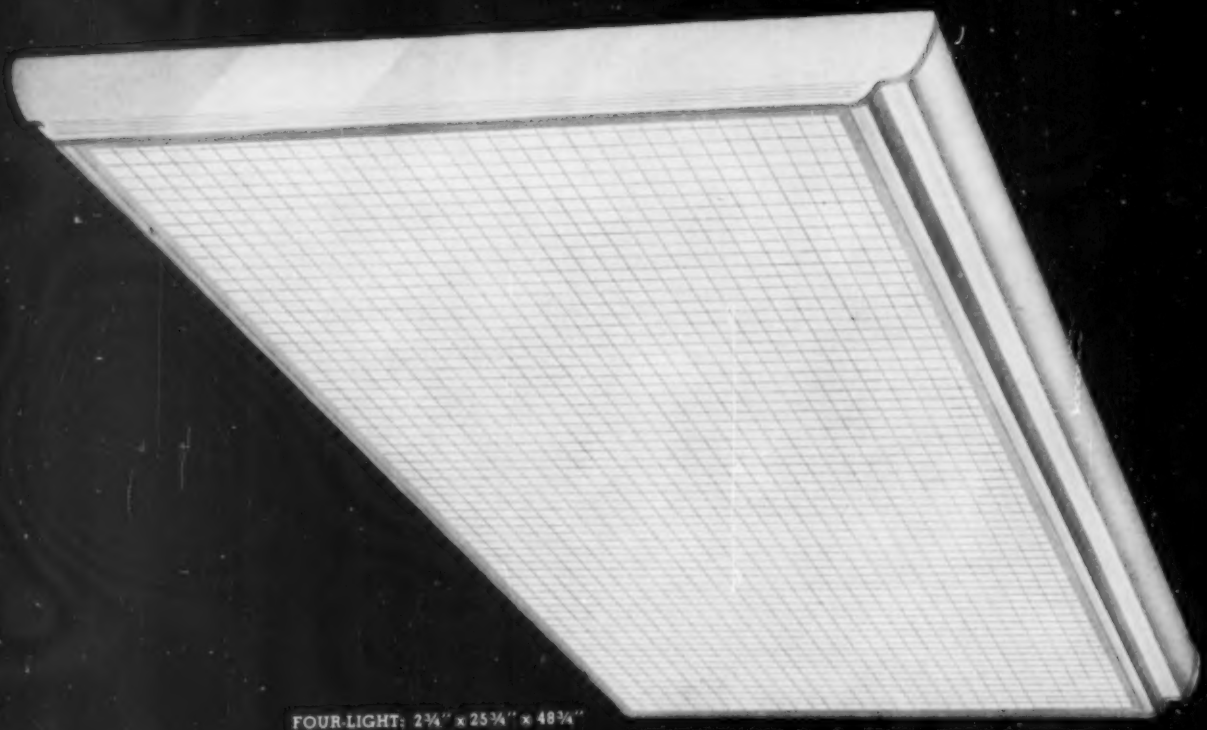
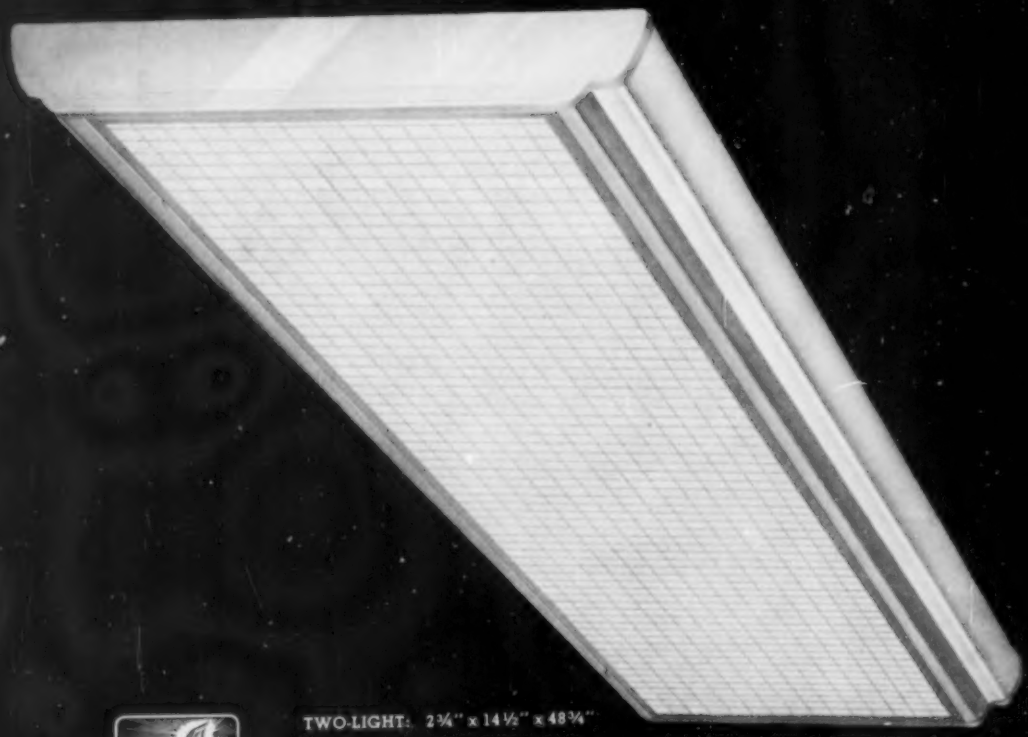


FOUR-LIGHT: 2¾" x 25¾" x 48¾"



TWO-LIGHT: 2¾" x 14½" x 48¾"

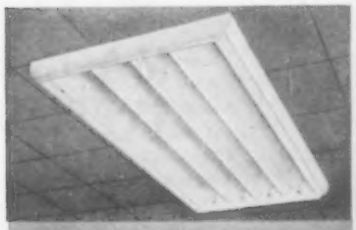
Gibson LIGHTING

GIBSON MANUFACTURING COMPANY

# the new Gibson Ceilo • 35

**ONLY 2¾" DEEP — AND NO DARK AREAS!**

In this striking new fixture, Gibson designers have achieved maximum thinness, with no dark panels or strips in the diffusing area. Parabolic reflectors and a unique way of mounting the ballasts provide a smooth, unbroken panel of light in a fixture of incomparable quality and beauty.



**PARABOLIC REFLECTORS**
The parabolic reflectors reflect all light straight down and thus provide an even distribution of light over the entire diffusing area.

**FINGER-TOUCH RELAMPING**
Just a touch of the fingertips to the louver latches allows the louver to swing open for relamping. Snap—and it's back in place.

Write today for complete information about the beautiful new Ceilo-35

Makers of the world's most versatile fixtures

ortho-77® 88®

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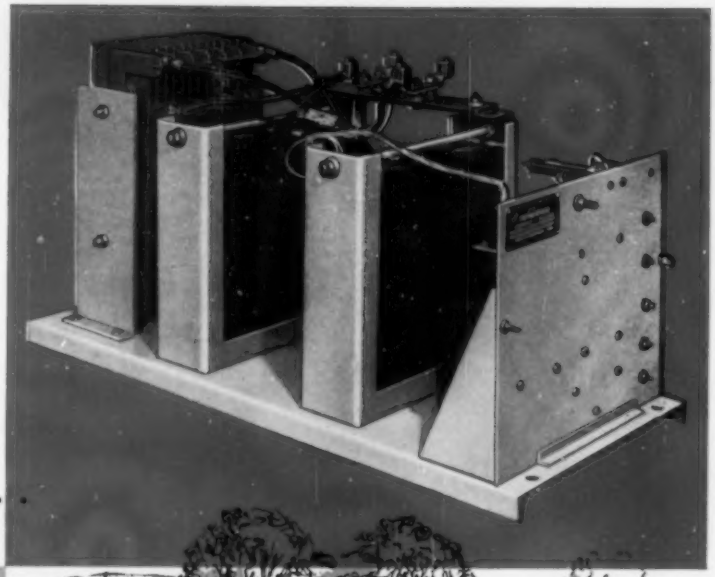
1919 Piedmont Circle, N.E., Atlanta 9, Ga.

# Modern Lighting Control *for the modern theatre . . . .*



PURDUE MEMORIAL UNION—
HALL OF MUSIC ANNEX
Lafayette, Ind.
Architects: Walter Scholer and Associates
Genl. Contractor: K. H. Kettelhut
Elec. Contractor: Hatfield Electric Company
Switchboard Manufacturer: Metropolitan Electric Manufacturing Company

Typical console manufactured by Lumi-Tron Division of Metropolitan Electric Manufacturing Co.

## VICKERS* MAGNETIC AMPLIFIER TYPE DIMMERS!

Maximum flexibility . . . rapid between-scene changes . . . accurate control of lighting intensities. These are important requisites of lighting control switchboards for the modern stage.

In Purdue University's magnificent new $9,000,000 Memorial Union—Hall of Music Annex (above), 80 Vickers Magnetic Amplifier Type Dimmers have been incorporated in the lighting systems for the Loeb Playhouse and the Experimental Theatre.

These dependable dimmers meet today's exacting lighting control needs with: fast response, smooth transition through the entire lighting range, new 30-1 load range, inherent stability, reduced weight and size through redesigned closed-core power section, elimination of tubes and moving parts, and other superior features.

Write today for 12-page bulletin on lighting control.

DESIGN ENGINEERS: Write for information concerning opportunities in our expanding program.

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## 1957 Regional Conferences, I.E.S.

| Region | Place | Date |
|---|---|---|
| Pacific Northwest | Empress Hotel<br>Victoria, British Columbia | March 28-29 |
| South Pacific Coast | Statler Hotel<br>Los Angeles, California | April 3-5 |
| Inter-Mountain | Alvarado Hotel<br>Albuquerque, New Mexico | April 11-12 |
| Southwestern | Holiday Inn<br>Oklahoma City, Oklahoma | April 28-30 |
| Midwestern | Pfister Hotel<br>Milwaukee, Wisconsin | May 9-10 |
| Great Lakes | Pantlind Hotel<br>Grand Rapids, Michigan | May 13-14 |
| Canadian | Sheraton Brock Hotel<br>Niagara Falls, Ontario | May 16-17 |
| East Central | William Penn Hotel<br>Pittsburgh, Pennsylvania | May 23-24 |
| Northeastern | Statler Hotel<br>New York, New York | June 13-14 |

(*Continued from page* 18A)

ing Sola engineering and research data, designs and patents.

**Clarence L. Snyder,** electrical engineer who pioneered in the study of storage batteries, has retired from the National Bureau of Standards, November 30, after 39 years of service.

Pittsburgh Reflector Co. has named **Frank E. Rickel** as Sales Manager of the firm. He will make his headquarters at the company's executive offices in Pittsburgh. Prior to his present appointment, Mr. Rickel was advertising and sales promotion manager.

**Leslie Mackie** has joined the Maritime office of Curtis Lighting, Inc., St. John, N. S. Mr. Mackie previously was in the contracting field, but has had a particular interest in lighting since winning the Maritime Chapter, I.E.S. contest for My Most Interesting Lighting Job, two years ago. With his increased interest, he has been elected Secretary-Treasurer of the Chapter. The St. John office of Curtis also handles the Miller Co. equipment and the Revere outdoor line, with coverage of New Brunswick, Nova Scotia and Newfoundland.

**Joseph Pellicano** has been appointed as McPhilben Lighting Co.'s sales representative in Oregon and Southern Idaho. Mr. Pellicano has offices at 1226 S. W. Hume St., Portland, Ore.

## Obituaries

**Van Rensselaer Lansingh,** Charter Member and seventh President of the Illuminating Engineering Society, died November 16th at his home in Stonington, Maine.

Sharing with Louis B. Marks the enthusiasm for establishing a Society devoted to the advancement of lighting, Mr. Lansingh assisted in organizing the first meetings which led to the formation of the Society in 1906. He was the Society's first Treasurer and was a Member and Chairman of many of its first, important committees.

Interested in education, Mr. Lansingh envisioned greatly widening possibilities for the development of formal instruction in illuminating engineering, and devoted the best of his life to the dissemination of lighting knowledge. He was responsible for organizing the famous lectures on optics and illuminating engineering at Johns Hopkins University, in 1910. With James Cravath, he was coauthor of one of the first practical text books on lighting, "Practical Illumination," published in 1907.

Following an active career as sales manager of the Holophane Company, and after his Presidency in 1912-1913, Mr. Lansingh's interests turned to the field of Metallurgy, and in this he continued until his retirement.

A Member Emeritus of the Society since 1949, he continued his interest in the Society's programs within the narrowing limitations of strength and physical ability during his final years.

**William A. D. Evans,** one of lighting's pioneers died September 13 in Summit, N. J. A member of I.E.S. since 1909, Mr. Evans was made Member Emeritus of the Society in 1947, upon his retirement from the General Electric Lamp Dept.

Mr. Evans was widely known in the early days of electric lighting through his pioneering work with the Cooper-Hewitt Electric Company, Hoboken, N. J. He first joined that company in 1903, serving as commercial engineer, vice-president, and in 1919 as president. He retained this position when the Cooper-Hewitt Electric Co. became the General Electric Vapor Lamp Company in 1939. When the company consolidated with the G-E Lamp Department in 1939, Mr. Evans moved to Nela Park where he served as a consultant in the Administration Division.

Mr. Evans' experience paralleled the development of electric discharge sources and his influence was widely felt in that field.

**T. Paul Gleeson,** charter member and Past-Chairman of the St. Louis Section, died November 27, at the age of 76. Mr. Gleeson was District Lighting Specialist for Westinghouse Electric Corp., until his retirement in 1947 after 40 years with the company. Later he was a lighting specialist with the Gamp Electric Co. of St. Louis and with the Art Metal Co. in their St. Louis office.

**William J. Dorrans,** Field Sales Manager of Curtis Lighting, Inc., was fatally injured on November 8 in a plane crash while attempting an emergency landing in the sand hills country near Taylor, Neb. Mr. Dorrans was 46.

**Henry Albrecht,** Alamo Chapter.
**Jacob Buchter,** New York Section.
**Charles Rupp,** San Jacinto Section.

## IT SEEMS TO ME

### Fluorescent Lamp Starters

We have read with great interest the article by W. H. Lake, "Glow Starter Design and Fluorescent Lamp Life," appearing in the October issue of ILLUMINATING ENGINEERING.

The subject of lamp performance and the effect of instant starting on lamp life

(*Continued on page* 24A)

(*Continued from page* 23A)

has always been of great interest to us as our air-thermal starter was specifically designed to prevent instant starting, as well as to provide for proper operation under wide temperature and voltage variations.

We would, however, like to take exception to the reference in the paper that air-thermal starters are both "fragile and costly." We have been manufacturing such starters since 1947 and are currently producing larger quantities than ever before. The cost price of our air-thermal starters, which are of the lockout type, is competitive with the glow switch lockout type and can be handled and shipped without any more care than that required by glow switch type starters.

Our air-thermal starters are ETL certified and conform to the new American Standards for fluorescent starters, which include the endurance test as a measure of durability as opposed to "fragility." Tests of our starters have proved that they will improve the average lamp life by as much as 150 per cent as well as equalize lamp life when used in conjunction with lead-lag preheat type ballasts. This in effect means that full rated lamp life can be best achieved and surpassed through their use.

We would like to point out further that users of our starters, which include large industrial and commercial consumers and government agencies, have found from experience that our air-thermal starters are the most economical starters they have ever used when defined in terms of savings brought about through improved lamp life and reduced maintenance costs.

We feel that Mr. Lake's article may have misled readers about the durability, availability and cost of air-thermal starters. We would be glad to furnish any data required to corroborate any statements we have made. — H. A. TALBERTH and W. B. MARTIN, *Engineers, Industrial Starter Corp., Brooklyn, N. Y.*

## Plastics in Lighting

In "Plastics for Lighting," in the November 1956 issue of ILLUMINATING ENGINEERING, the authors have produced a comprehensive summary which will be of value to the lighting industry. Unfortunately, their weatherability rating of the various plastics (Table I—Properties of Plastics Used in Light Control) is not borne out in exposure tests by Rohm & Haas Company. Applying the identical rating of "good" to acrylics and to general purpose and heat-resistant styrene is misleading. The proven ability of the acrylics to withstand continuous outdoor exposure in such applications as fluorescent street lighting, signs, dome skylights, glazing, aircraft enclosures and exterior automobile parts is not shared by other transparent plastics.

Based on long term outdoor exposure data, I believe the acrylics should have been rated as "superior" or "excellent" in Table I of the article. — H. A. WILLIAMS, *Rohm & Haas Company, Plastics Department, Philadelphia, Pa.*

**GUEST SPEAKER at the November meeting of the Tar Heel Section of I.E.S. was John Page, National Field Representative of the National Adequate Wiring Bureau, who is shown here (standing) with the Section's Board of Managers. L. to r.: Dick Marshall; Coy Jordan; Jim Cardo; John Page; Andy Ducker, Section Chairman; George Stevens and Jim Lowe. The meeting was held at the Duke Power Co. building, Charlotte, N. C.**

# BOOKS AND PAMPHLETS

**1956 Supplements to Book of ASTM Standards,** published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. In seven parts; $4.00 per part; $28.00 per set.

The seven sections of these 1956 supplements are: (1) Ferrous Metals; (2) Non-Ferrous Metals; (3) Cement, Concrete, Ceramics, Thermal Insulation, Road Materials, Waterproofing, and Soils; (4) Paint, Naval Stores, Woods, Sandwich Construction, Building Constructions, Fire Tests, Wax Polishes; (5) Fuels, Petroleum, Aromatic Hydrocarbons, Engine Antifreezes; (6) Rubber, Plastics, Electrical Insulating Materials; (7) Textiles, Soap, Water, Paper, Adhesives, Shipping Containers, Atmospheric Analysis.

**How Mercury Vapor Outdoor Lighting Brings More Night Action,** 8-page booklet, available from Sylvania Electric Products Inc., 60 Boston St., Salem, Mass.

Designed for markets such as railroads, transit companies, oil companies, refineries, steel mills, supermarket chains, this booklet illustrates the use of mercury vapor lamps in such locations as service stations, shopping centers, transportation terminals parking lots, industrial areas, billboards and displays.

**Step Voltage Regulators,** Bulletins GEA-5752C and GEA-6552, available from the General Electric Co., Schenectady 5, N. Y.

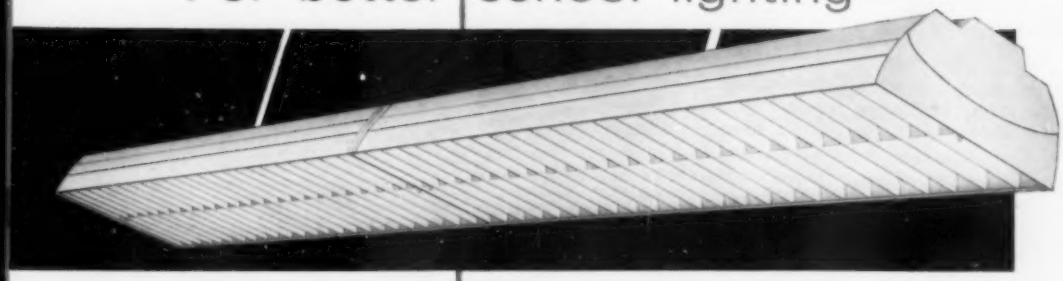
Descriptive data on design features, applications, wiring diagrams and electrical data for 20 single-phase ratings and 77 three-phase ratings are given in these booklets. Both brochures on step regulators plus one on induction feeder regulators are included in a single package, "Your Guide to Profitable Voltage Regulation," GED-3133.

**Prescribed Lighting Protects the Eyes of Industry,** 28-page booklet, available from Sylvania Electric Products Inc., Wheeling, W. Va.

Three-color illustrated brochure has features on safety and visibility factors; standards for use in prescribing plant lighting; uses of fluorescent, incandes-

(*Continued on page* 26A)

For better school lighting --



## THE KEY VISUAL AID

Education used to be largely a matter of hearing and reciting. Today's children, however, learn by *seeing* and *doing*. The visual techniques of modern teaching demand the very best in classroom lighting. Good lighting is essential—to protect young eyes at work, to make the learning process more efficient, to create an atmosphere of cheerful cooperation between teacher and student. This is why architects and school authorities across the country have chosen the Miller "Lexington" as the standard of quality for contemporary classroom lighting.

If you have a new school in the planning stage, let us help you with expert advice and detailed information on the lighting best fitted to your needs.

PARTICIPATING IN SCHOOLROOM PROGRESS U.S.A.

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SINCE 1844

*Better Lighting for a Brighter America*

THE MILLER COMPANY: GENERAL OFFICES, MERIDEN, CONN.
FACTORIES: UTICA, OHIO—MERIDEN, CONNECTICUT.
IN CANADA: CURTIS LIGHTING OF CANADA LTD. TORONTO.

(Continued from page 24A)

cent and mercury vapor lamps; lighting of other areas, and maintenance. Lighting for special seeing tasks, and lighting of non-production areas, protective and yard lighting, and infrared lamps in industry are also described and illustrated.

**Infrared Lamps and Their Applications,** Bulletin LS-128, available from the Large Lamp Dept., General Electric Co., Cleveland 12, Ohio.

# NEW MEMBERS

At the meeting of the I.E.S. Council held at New York, N. Y. on December 12, 1956, the following were elected to membership. Names marked * are transfers from Associate Member Grade.

### ALABAMA SECTION

*Members:*

*Martin, W. C., Jr., Alabama Power Co., Birmingham, Ala.
*Pride, J. G., Alabama Power Co., Mobile, Ala.

*Associate Members:*

Copeland, G. R., Alabama Power Co., Mobile, Ala.
Davis, E. R., Jr., Alabama Power Co., Enterprise, Ala.
Flowers, C. A., Alabama Power Co., Atmore, Ala.
Reed, A. C., Alabama Power Co., Mobile, Ala.
Springer, J. E., Alabama Power Co., Mobile, Ala.
West, J. D., Alabama Power Co., Mobile, Ala.
Wills, L. T., City of Birmingham, Birmingham, Ala.

### ARIZONA SECTION

*Member:*

*Williams, J. R., Arizona Public Service Co., Phoenix, Ariz.

*Associate Members:*

Davis, J. W., Westinghouse Electric Supply Co., Phoenix, Ariz.
Osborn, W. C., 4542 N. 18th Dr., Phoenix, Ariz.
Parrish, W. E., Arizona Wholesale Electric Co., Phoenix, Ariz.
Thorne, E. V., T & R Construction Co., Inc., Phoenix, Ariz.

### BRITISH COLUMBIA SECTION

*Associate Members:*

Borton, R. H., Brettell Electric Ltd., Vancouver, B. C.
Bradley, H. B., Canadian General Electric Co., Vancouver, B. C.
Cowan, J. M., B. C. Fluorescent Sales & Service Ltd., Vancouver, B. C.
Harrison, W. F., F. N. Adams & Co. Ltd., Vancouver, B. C.
MacLennan, R. J., F. N. Adams & Co. Ltd., Vancouver, B. C.
Webster, F. C., B. C. Electric Co. Ltd., Abbotsford, B. C.

### CAPITAL SECTION

*Associate Member:*

Becker, F. M., Jr., Becker Electric, Alexandria, Va.

### CENTRAL NEW YORK SECTION

*Associate Member:*

Straub, F. J., Robson & Woese, Inc., Syracuse, N. Y.

### CENTRAL OKLAHOMA CHAPTER

*Associate Members:*

Brown, C. B., Westinghouse Electric Supply Co., Oklahoma City, Okla.
Higgins, C. H., Higgins Acme Neon Inc., Oklahoma City, Okla.
McFarlane, Warren, Traweek Healy & Associates, Dallas, Texas.

### CHICAGO SECTION

*Members:*

Cabernoch, L. J., Electro Silv-A-King Corp., Chicago, Ill.
*Strecker, C. E., General Electric Co., Danville, Ill.

*Associate Members:*

Dimmett, R. J., Curtis Lighting Inc., Chicago, Ill.
Long, D. A., Illinois State Toll Highway Commission, Chicago, Ill.
Major, F. A., Major Equipment Co. Inc., Chicago, Ill.
Mors, R. J., Benjamin Electric Mfg. Co., Des Plaines, Ill.
Nounnan, J. F., Jr., General Electric Co., Chicago, Ill.
Shreck, C. M., Curtis Lighting Inc., Chicago, Ill.

### CHINOOK CHAPTER

*Member:*

*McKenzie, R. B., 706 3rd Ave. S., Lethbridge, Alta.

### CLEVELAND SECTION

*Members:*

Buus, B. R., General Electric Co., Cleveland, Ohio.
Farrington, R. K., The Thompson Electric Co., Cleveland, Ohio.
Jordan, Paul B., General Electric Co., Cleveland, Ohio.
*Noel, E. B., General Electric Co., Cleveland, Ohio.
Pearson, C. W., General Electric Co., Cleveland, Ohio.
Smith, R. J., General Electric Co., Cleveland, Ohio.

*Associate Members:*

Bauer, H. J., Westinghouse Electric Corp., Cleveland, Ohio.
Cooper, R. L., General Electric Co., Clevealnd, Ohio.
Johnston, C. W., Westinghouse Electric Corp., Cleveland, Ohio.
Thorpe, D. W., General Electric Co., Cleveland, Ohio.

### CONNECTICUT SECTION

*Associate Members:*

Harper, C. C., General Electric Co., New Haven, Conn.
Tiso, P. M., Lighting Services, Waterbury, Conn.

### CORNHUSKER CHAPTER

*Member:*

*Haas, C. P., General Electric Co., Omaha, Nebr.

### EASTERN PENNSYLVANIA SECTION

*Members:*

Breman, H. H., Pennsylvania Power & Light Co., Allentown, Pa.
*Staudt, C. B., Pennsylvania Power & Light Co., Pottsville, Pa.

*Associate Member:*

Prince, LeRoy, Fluorescent Supply Co., Harrisburg, Pa.

### FOREIGN NON-SECTION

*Member:*

*Mounter, F. W., The General Electric Co. of India (Pvt), Ltd., Calcutta, India.

### GEORGIA SECTION

*Associate Members:*

Bainbridge, F. F., Toombs, Amisano & Wells, Atlanta, Ga.
Carmichael, R. L., Graybar Electric Co., Atlanta, Ga.
Foster, H. H., Jr., Georgia Power Co., Atlanta, Ga.

### GOLDEN GATE SECTION

*Member:*

*deLeuze, Guy, Guy deLeuze Co., San Francisco, Calif.

*Associate Members:*

Cain, J. M., Ruby Lighting Co., San Francisco, Calif.
Casey, L. F., Jr., Casey Electric Co., San Francisco, Calif.
Komor, L. A., Sylvania Electric Products Inc., Burlingame, Calif.
Osterman, Bert, United Lighting & Ceiling Co., Oakland, Calif.
Parker, D. G., Grey Electric Supply Co., San Francisco, Calif.
Smith, W. G., Smith Electric Co., San Francisco, Calif.

### HAMILTON, ONTARIO CHAPTER

*Associate Members:*

James, Q. W., H. K. Walter & Associates Ltd., Kitchener, Ont.
Nagy, F. L., Masco Electric Co., Ltd., Hamilton, Ont.

### HEART OF AMERICA SECTION

*Associate Members:*

Hollis, R. H., 8113 Mackey, Overland Park, Kans.
Shea, R. M., Sylvania Electric Products Inc., Kansas City, Kans.

### MARITIME CHAPTER

*Associate Member:*

Martin, R. H., Northern Electric Co. Ltd., Moncton, N. B.

### MEXICO CHAPTER

*Associate Member:*

Vargas, J. A., Impulsora Electrica Nacional. Mexico, D. F.

*Student Members:*

Maksabedian, A., Jorge, Monte Alban 40, Mexico, D. F.
Mena, G. L., Luz Savinon 1310, Mexico, D. F.

### MICHIGAN SECTION

*Members:*

Hirst, S. J., Madison Electric Co., Detroit, Mich.
Konar, A. F., University of Michigan, Ann Arbor, Mich.

*Associate Members:*

Bedtelyon, A. F., Consumers Power Co., Flint, Mich.
Egigian, Peter, Detroit Edison Co., Detroit, Mich.
Gleason, J. B., Benfield Detroit Co., Detroit, Mich.
Maison, K. P., Crescent Electric Co., Detroit Mich.
Maitre, J. B., Detroit Edison Co., Detroit, Mich.
O'Donnell, S. F., Argonaut Realty Div., General Motors Corp., Detroit, Mich.
Renkiewics, Raymond, Block & Mullkoff, Ferndale, Mich.
Roth, Blume, Roth Electrical Supply Co., Flint, Mich.
Scott, C. L., Crescent Electric Co., Detroit, Mich.
Staggers, T. R., General Electric Co., Detroit, Mich.
Stewart, J. S., Consumers Power Co., Saginaw, Mich.
Taylor, Edward, Argonaut Realty Div., General Motors Corp., Detroit, Mich.

### MILWAUKEE SECTION

*Associate Members:*

Bruno, P. R., Sylvania Electric Products Inc., Milwaukee, Wis.

(Continued on page 42A)

## new luminaire . . .

## with light-control lens of Plexiglas

Molded of PLEXIGLAS® acrylic plastic, the prismatic enclosure of this recently introduced fluorescent luminaire contributes many basic design advantages:

**Light Weight and Strength** make possible a simplified design notable for the absence of heavy metal framing . . . resulting in slim, compact, architecturally harmonious appearance. The entire lens section is hinged, can be swung down for easy relamping and cleaning.

**Shatter Resistance** makes the luminaire especially suitable for locations where safety is a prime requisite.

**Precise Moldability** to the lens pattern results in an efficient optical element that provides a high level of downward light and, at the same time, complete visual comfort.

**Dimensional Stability and Freedom from Discoloration** insure long term efficiency, beauty and economy.

Write today for the names of manufacturers of fluorescent luminaires featuring molded PLEXIGLAS enclosures.

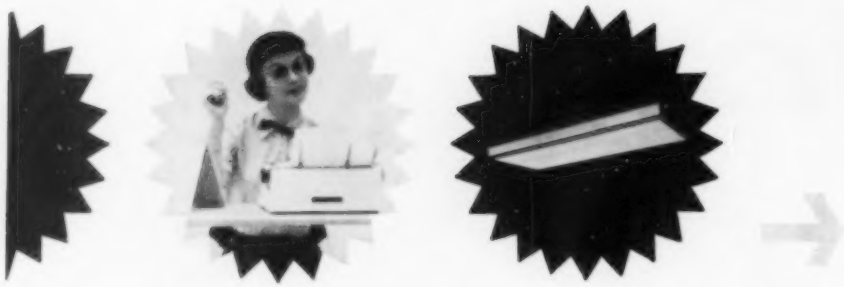
*Chemicals for Industry*

**ROHM & HAAS COMPANY**

**WASHINGTON SQUARE, PHILADELPHIA 5, PA.**

*Representatives in principal foreign countries*

**Canadian Distributor:** *Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Canada.*



# VERSA-LUX.

There's unmatched versatility in this *new* Versa-Lux family, together with a designed-in simplicity of straight-line styling that will satisfy any lighting need.

Wide unbroken surface planes, made possible by rigid hinged steel doors, provide maximum visual continuity. Doors with center mullions are also available to provide a greater selection of media.

Versa-Lux—in two widths for two, four and six lamps*—is *now* available with these glass and plastic lens and panel closures—Holophane Lo-Brite® Controlens® #6016 Flat Plastic, #9016 Flat Crystal, Dished Crystal, Corning #93 Alba-Lite, Polystyrene Plastic Egg-Crate, Honeylite® aluminum louver, or Flat Acrylic Plastic—all of them with fine-ribbed plastic side panels. Versa-Lux installation is simple and versatile; maintenance is minimal.

No matter what kind of lighting you're looking for, at whatever price—Versa-Lux can be the answer, for its versatility is limited only by your own imagination, and its price is set to meet any budget.

**Rapid Start only.*

*Versa-Lux specifications available on request.*

*®Holophane Co., Inc. ®Hexcel Products, Inc.*

**CURTIS LIGHTING, INCORPORATED**

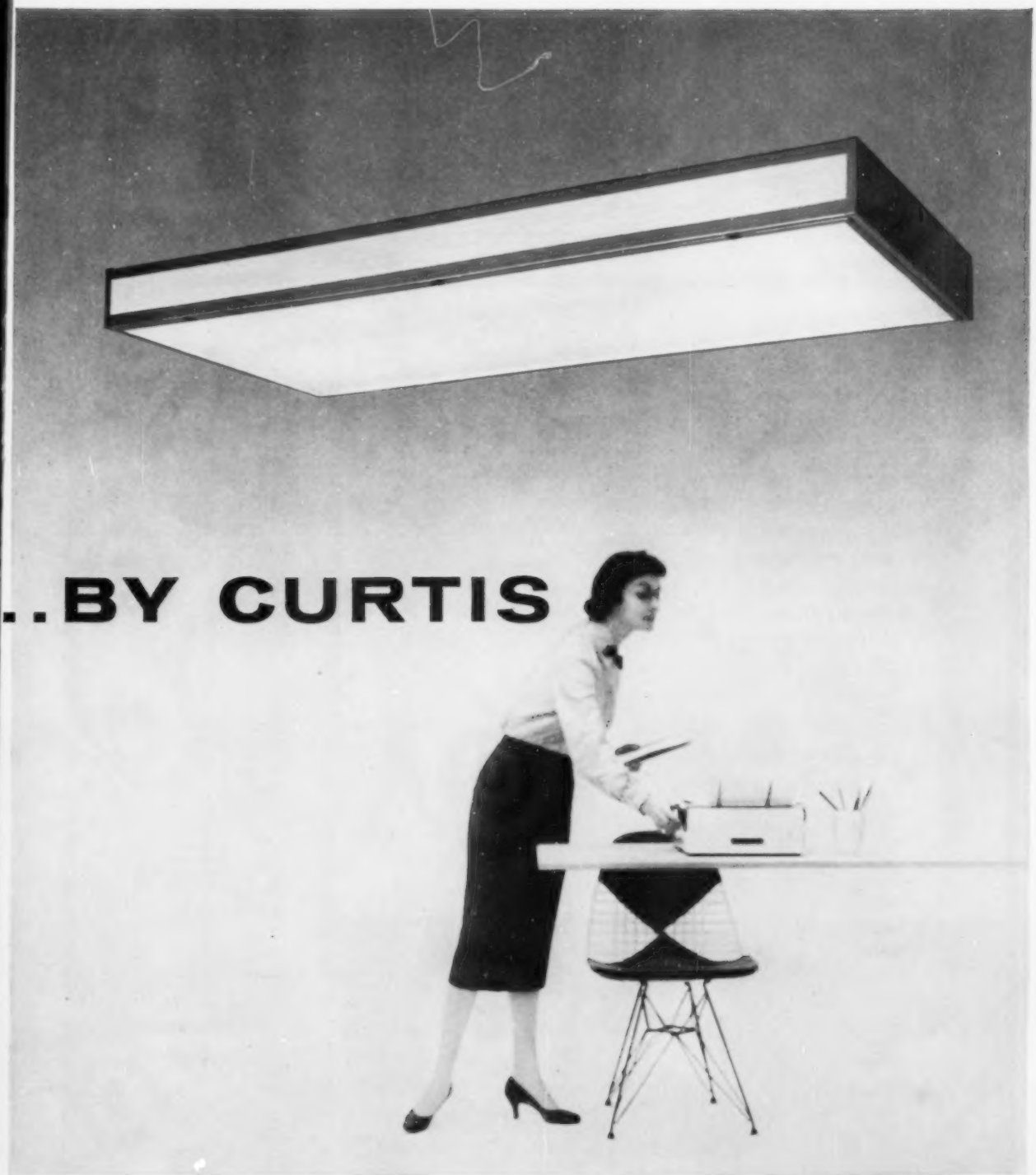
6135 West 65th Street, Chicago 38, Illinois

**Versatile Versa-Lux install them direct-ceiling-mount, partially recessed or pendant mount, individually, in continuous lines or in patterns.**

SURFACE MOUNT PARTIALLY RECESSED PENDANT MOUNT

CURTIS

**In California: 242 S. Anderson St., Los Angeles 33, California • In Canada: 195 Wicksteed Ave., Toronto 12, Canada**



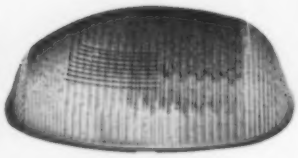
# ..BY CURTIS

TWO LAMPS

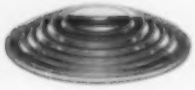
FOUR LAMPS

SIX LAMPS

Versatile Versa-Lux/available in two widths for two, four and six lamps and seven different bottom closures.



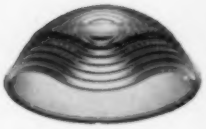
Street light refractor



Railroad signal lens

High intensity runway marker

12" traffic signal lens



Airport taxi-way marker lens

From the giant steel fingers of radio and television towers come wave lengths that give us information, entertainment and companionship. Towers in excess of 150 feet height are topped with a flashing beacon and the structure is outlined with steady red warning lights. Corning heat-resisting glassware that withstands the elements, transmits true color and closely controlled beam pattern, keeps aircraft at a safe distance.

Corning produces many special items which make travel safe, be it by land, sea or air.

**CORNING GLASS WORKS**
**CORNING, NEW YORK**

*Corning means research in Glass*

# A NEW DIMENSION IN LIGHTING

# SHALLORAMA®

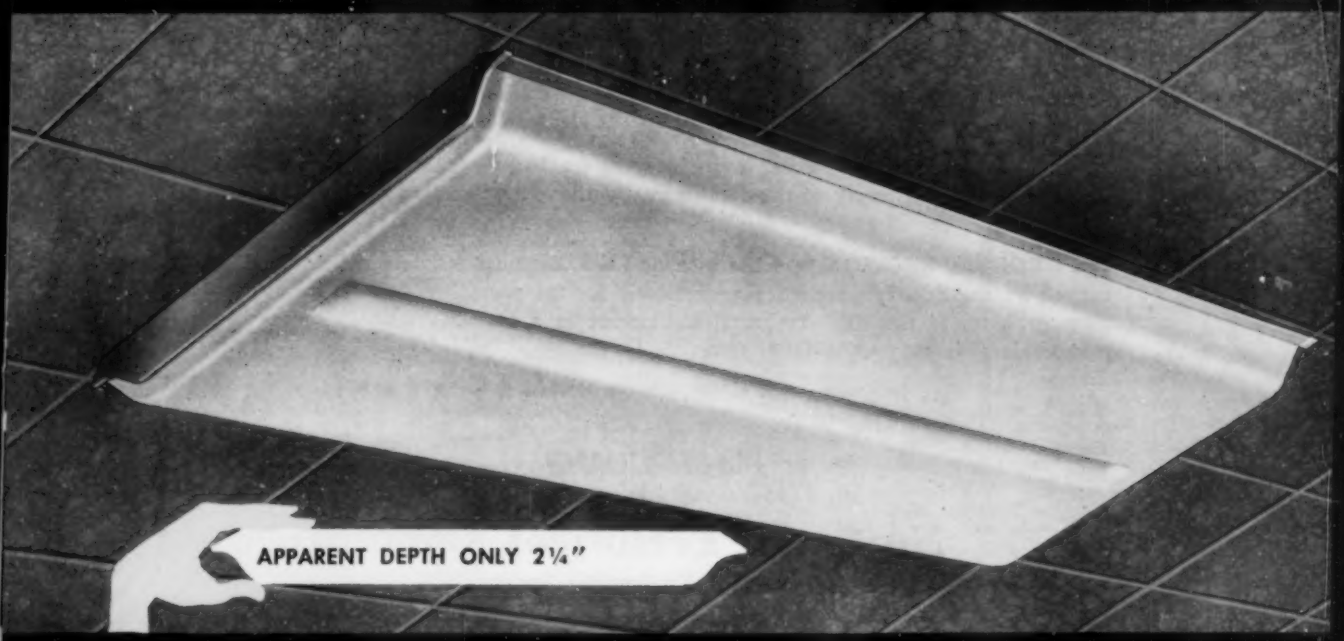
A revolutionary new, extremely shallow surface-mounted Visionaire®, the SHALLORAMA brings new dimensions to architectural illumination.

An incomparably shallow, self-luminous structural element, fully enclosed by contoured matte white Plexiglas for soft even brightness and efficient "area" illumination. Blends with ceiling for recessed appearance.

Vast range of application: for new or remodeled interiors, for offices, stores, banks, institutional areas, etc.

No latches, no hinges, no visible hardware to mar the SHALLORAMA beauty; diffuser opens from either side with one hand on continuous hinge support.

Years ahead engineering exemplified by reflector-lamp-diffuser relationships and air spaced separation of ballast mounting surface from ceiling.




Patent Pending

Integral, jack-type levelling device compensates for uneven ceilings and facilitates precision alignment in continuous rows. Write for colorful, descriptive Bulletin 763.

SUNBEAM LIGHTING COMPANY, 777 EAST FOURTEENTH PLACE, LOS ANGELES 21, CALIFORNIA

# We're busy planning big things for *YOU* in *ATLANTA!*

**The National Technical Conference Executive Committee* at work in a planning session for the 1957 Conference of the Illuminating Engineering Society in Atlanta, Georgia.**

**Left to right: Rita Kuzell, Ladies; Judd Lough, Finance; Emily Alexander, Ladies; Al E. Bruner, Sports; J. E. Sweatte, Hotel; Mary Bush, Ladies; W. M. Pearson, Chairman, Georgia Section; Joe B. Browder, Chairman, 1957 Conference Executive Committee; Jim Forbes, Chairman, I.E.S. National Technical Conference Committee; Dex Hinckley, Executive Secretary, I.E.S.; Jack Murrah, Publicity; Jack Burns, Entertainment; John Brun, Manager Georgia Section; Cecil Canon, Reception.*

**ATLANTA is a showcase and nerve center of the New South—it's a city full of push and purpose, of such booming business that it's spreading a pattern of progress throughout Georgia and the Southeast, but . . .**

**ATLANTA is, at the same time, a city of gracious living, of beautiful homes, and year-round gardens, with plenty of the traditional Southern hospitality.**

**The GEORGIA SECTION was the pioneer I.E.S. organization in the Southland and has carried on the Society's activities aggressively for the past 17 years. Its members plan to serve as hosts to the 1957 Technical Conference in a fashion that will surpass even the memorable 1941 convention in Atlanta.**

*Y'ALL COME!*

## 1957 National Technical Conference

Illuminating Engineering Society

**Headquarters:**

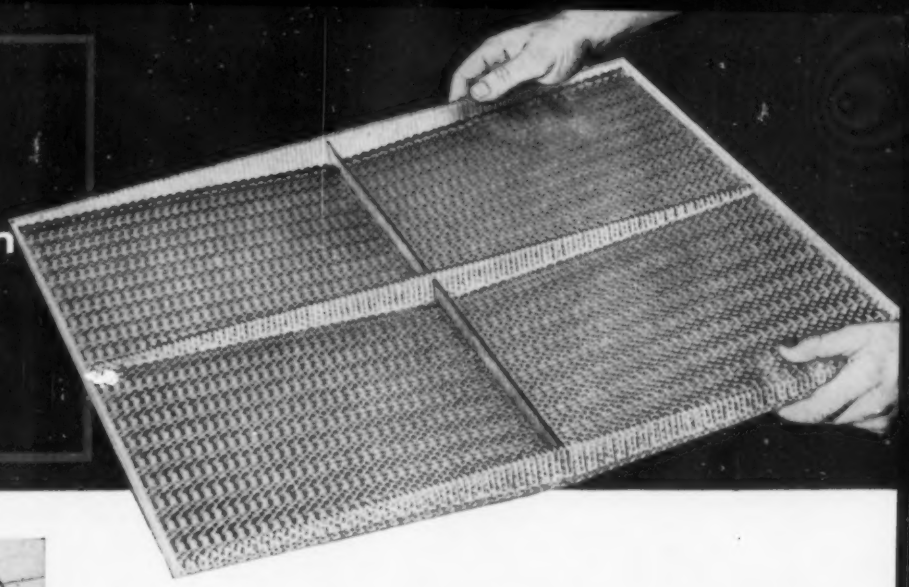
Atlanta Biltmore Hotel

"The South's Supreme Hotel"

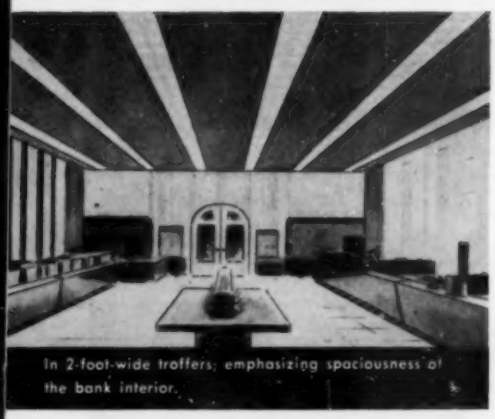
**Dates:**

September 9 thru 13, 1957

# HOLOPHANE ENGINEERS Break Through the GLARE BARRIER...



No. 6024 in large ceiling panels; effective lighting for executive offices.



In 2-foot-wide troffers; emphasizing spaciousness of the bank interior.

Small and large panels in the store ceiling; excellent illumination for seeing and selling.

## Prismalume* Controlens* No. 6024 Introduces New Concepts in Fluorescent Light Control

There's a new trend in lighting — heralded by this two-foot-square HOLOPHANE CONTROLENS*. . . It produces the highest illumination with complete visual comfort! With your first step into an interior illuminated by this CONTROLENS you sense that something new and stimulating has been achieved with the lighting . . .

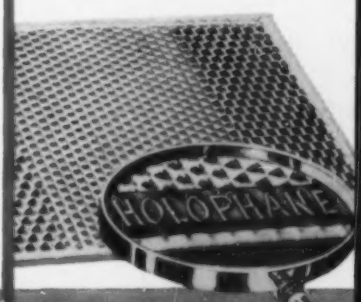
Due to prismatic control, maximum light is delivered on the work plane. This CONTROLENS can be used in two-foot-wide troffers (continuous runs), geometric groupings, or large luminous panels . . . Its sleek, handsome design conforms with the modern decor of offices, banks, stores, lobbies, showrooms, auditoriums and an unlimited variety of other areas. Write for complete engineering data today.

*For Better Lighting* Holophane *... Be Specific*

*Trademark

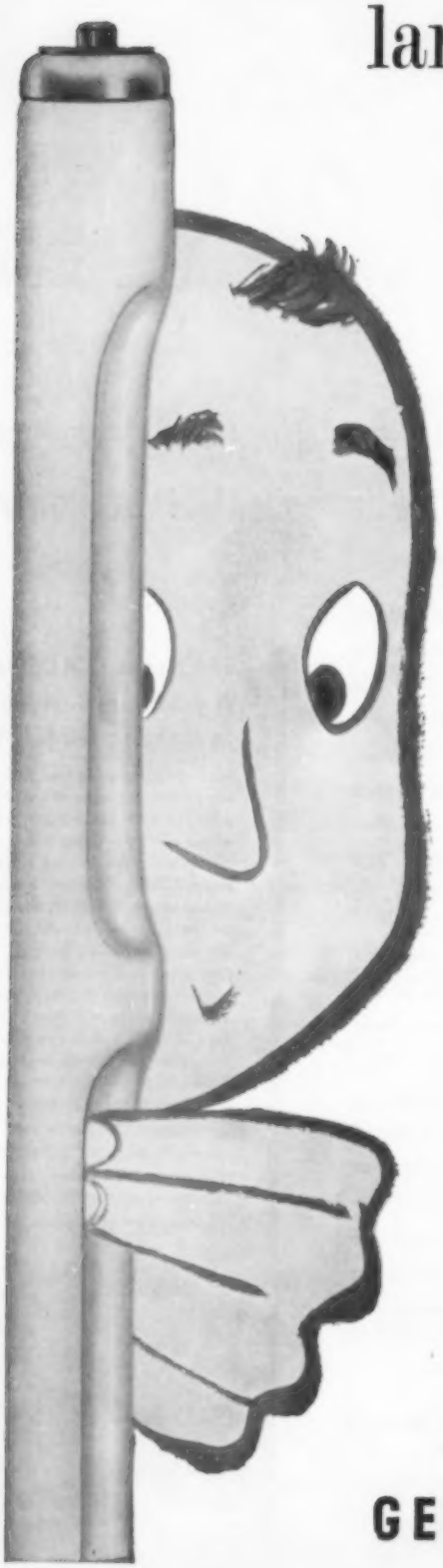
### *The Name* HOLOPHANE *is your Surest Guide to Lighting* QUALITY

High-speed pressing and rolling are cost-cutting ways of making prismatic panels—acceptable only where quality is unimportant . . . This is definitely *not* the Holophane method. Every HOLOPHANE lens is carefully and *individually* pressed on specialized equipment. Only by this painstaking process can we make prismatic forms accurate enough to direct light precisely where it is needed. HOLOPHANE Lenses are the basic components of *custom-engineered* illumination systems, specifically designed for each lighting requirement . . . To be sure of quality in prismatic CONTROLENS* Refractors or Reflectors, look for the name "HOLOPHANE" impressed on each piece.




**HOLOPHANE**
**COMPANY, INC.** • *Lighting Authorities Since 1898*
342 Madison Ave., New York 17, N.Y.
THE HOLOPHANE CO., LTD., 415 RIPLING AVE. SO., TORONTO 14, ONTARIO

# The shape of fluorescent lamps to come



## New General Electric "Power-Groove" discovery means more light for you . . . at less cost

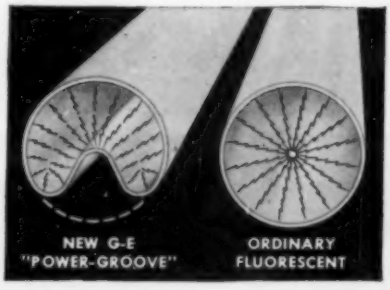
Look at this new kind of fluorescent lamp. It's the General Electric "Power-Groove"—a revolutionary new development created by G-E engineers. It not only gives more than 2½ times as much light as the 8-foot slimline (most widely used 8-foot fluorescent), and lets you save more than 20% on your initial cost, and has fewer parts to maintain . . . but it even *looks* different—for a reason.

*It's the grooves in General Electric "Power-Groove" Lamps that make possible a greater increase in light-per-foot than all the combined increases made since General Electric introduced fluorescents in 1938!*

The new G-E "Power-Groove" Lamps are the popular 8-foot length (200-watts) with 4-foot sizes also available and 6-foot sizes later. They are Rapid Start lamps that need no starters—and are to be used in fixtures and circuits designed especially for them.

**IF YOU'RE PLANNING** a new lighting installation—you'll want to investigate G-E "Power-Groove". New G-E "Power-Groove" lamps are going into some installations right now! You'll be able to buy them . . . and the fixtures . . . in quantity by midsummer, so get the whole story now. Call your local G-E Lamp Supplier or write: General Electric Co., Large Lamp Dept., Nela Park, Cleveland 12, Ohio.

**COMPARE!** The new G-E "Power-Groove" construction (left) works 3 ways to give more light. One: it places some of the light-producing phosphors closer to the energizing area in the center of the lamp. Two: it presents a greater surface area which permits the generation of more ultraviolet rays to activate the phosphor. And three: it makes the lamp run cooler—which permits a higher current design and gives you more light per watt.




*Progress Is Our Most Important Product*

GENERAL ELECTRIC

Luminaires of Du Pont LUCITE manufactured by The Miller Company, Meriden, Connecticut, use 1' x 4' low brightness lenses injection-molded by Prolon Plastics Division of the Pro-phy-lac-tic Brush Company, Florence, Massachusetts. Known as "The Hartford," these luminaires illuminate the new district headquarters building of the Virginia Electric and Power Company, Norfolk.

# *Better looking, better lighting*

# with luminaires of Du Pont LUCITE®

The Virginia Electric and Power Company, which provides electric service to a large part of the state of Virginia, recently constructed a modern division headquarters building in Norfolk, Virginia, in which 77% of the lighting fixtures are of Du Pont LUCITE.

Lenses made of crystal-clear LUCITE acrylic resin refract light efficiently and evenly . . . transmit optimum light without specular glare or shadow. They are strong, durable, free from discoloration and dimensionally stable. In addition, lenses made of LUCITE are shatterproof, light in weight, easy to handle and install.

Because of these outstanding features, LUCITE is being utilized in practically all types of modern lighting installations: modular light-diffusing panels, large-area lighting, low-brightness lenses for troffer and pendant luminaires, side panels, cove lighting enclosures, and protective covers for outdoor lighting fixtures.

Why not evaluate the advantages of incorporating LUCITE into your lighting designs? For property and application data send for booklet at right.

**SEND FOR FREE BOOKLET.** This 12-page, illustrated booklet describes the latest property and application data on LUCITE acrylic resin for lighting. For your free copy, write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 431, Du Pont Building, Wilmington 98, Del.

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...*THROUGH CHEMISTRY*

# Now... a luminaire that operates in freezing temperatures!

The new Westinghouse LT operates in low or variable temperatures — making it ideal for lighting cold storage warehouses, food lockers, shipping platforms and marquees.

Designed in cooperation with the Refrigeration Institute, the Westinghouse LT luminaire gives low heat output and high light output. A clear, ribbed plastic enclosure protects the lamp from air currents to insure maximum efficiency of the F72T-12, 100-watt, rapid-start lamps. In addition, the LT's porcelain finish resists corrosion in moist atmospheres and enhances its appearance. Why gamble with fixtures that were designed for other purposes.

Doesn't the LT suggest an application to you?

For real lighting quality, specify the Westinghouse LT luminaire.

See your Westinghouse distributor or write, Westinghouse Electric Corp., Lighting Division, Edgewater Park, Cleveland, Ohio.

Look for other new Westinghouse lighting products . . . soon to be announced!

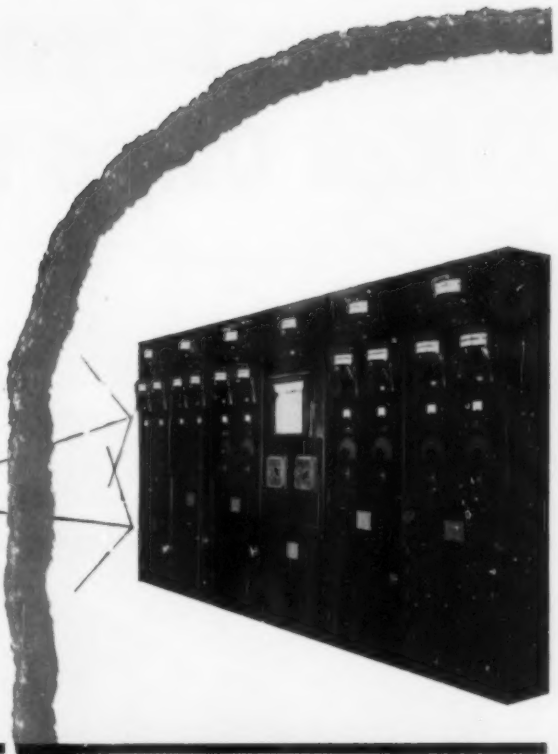
J-04399-B X

## WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU!***

meet
the
mastermind
behind

# KSH

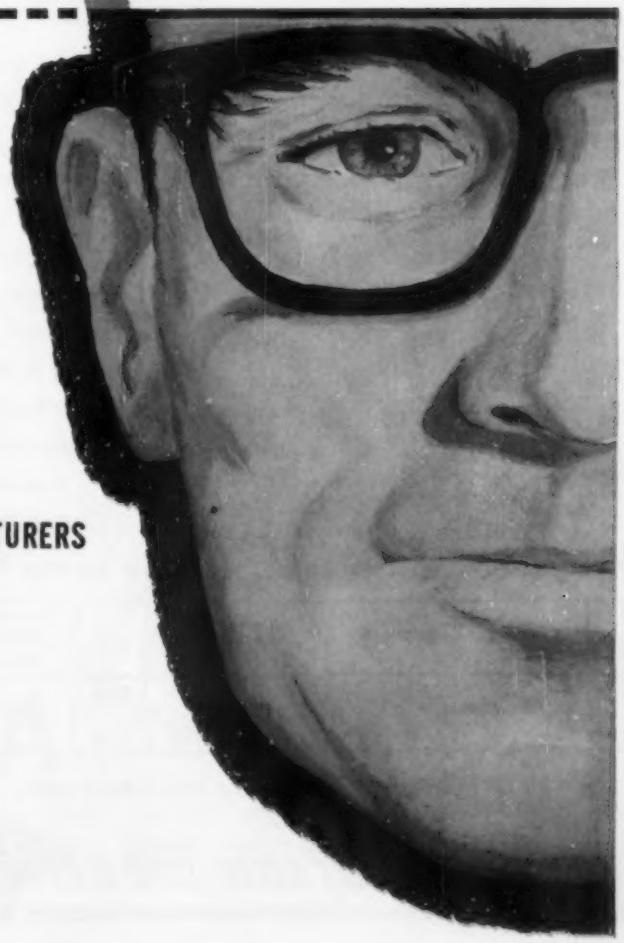


## PRECISION EXTRUSIONS

With the KSH electronic control center on the alert; every die and heating element is kept under rigid control. Extrusions are absolutely uniform run after run after run.

When you must have precision in your plastic parts... contact KSH!

**DESIGNERS • ENGINEERS • MANUFACTURERS**



KSH
SALES OFFICES

**KSH PLASTICS, INC. • HIGH RIDGE, MO.**

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DAYTON, OHIO • ATLANTA, GA. • GRAND RAPIDS, MICH.
ST. LOUIS, MO. • WASHINGTON, D. C. • BOSTON, MASS.

# Jefferson Ballast for 800 MA High Output Fluorescent Lamps

This Jefferson ballast is designed to give you Full-Rated light output as specified by the lamp manufacturer.

Only Jefferson has succeeded in *designing* and *manufacturing* a ballast for two HO 96T12/RS or two HO 72T12/RS lamps capable of giving *full light* output.

Applications include medium and high bay industrial and commercial locations where high output is required.

It is recommended that surface mounted fixtures be checked for conformance to UL temperature requirements.

*Remember*—for full light output from the new High Output lamps, insist on Jefferson Ballast No. 254-721!

**COMPLETE BALLAST SELECTION DATA**

New Technical Bulletin B560-10 gives complete selection data on the entire Jefferson Ballast line in compact, easy-to-use form. Write for your copy today!

**PRIMARY 118 VOLTS*—60 CYCLES—HIGH POWER FACTOR**

| Catalog No. | Watts | Lamps | MA | Approx. Watt Loss | Sound Group | Minimum Operating Temperature | Net Weight |
|---|---|---|---|---|---|---|---|
| 254-721 | (2)100/105 | (2)96T12/RS | 800 | 38 | F | +50°F | 13 Lbs. |
| | (2)85 | (2)72T12/RS | 800 | | | −20°F | |

Length 14 5/16", Width 3⅛", Height 2⅝", Mtg. Centers 13¾".

*For 277 Volt lines, specify Catalog No. 254-728.

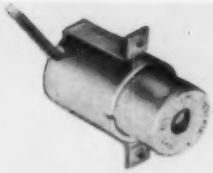
**Jefferson Electric Company**

BELLWOOD, ILLINOIS

Channel Screw Terminal Type
for T-8 Lamps

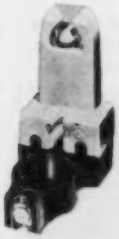
Channel "Quick Connect" Type
Rear Terminal Tabs for T-8 Lamps

Channel "Quick Connect" Type
Front Terminal Tabs for T-8 Lamps



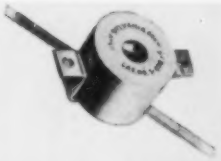
Slimline Plunger—Butt-on
High Voltage End Lead Terminal Type
—with or without mounting bracket
for Slimline Lamps

Medium—Single Screw Terminal
Type for T-8 and T-12 Lamps



Medium—Combination Screw Terminal
Type for T-8 and T-12 Lamps

Medium—Butt-on
Lead Terminal Type
for T-8 and T-12 Lamps



Slimline Plunger—Butt-on
Low Voltage End Lead Terminal Type
—with or without mounting bracket
for Slimline Lamps

Sylvania fills every basic need for

# Fluorescent Wiring Devices

Slimline—Butt-on High Voltage End
Screw Terminal Type
for Slimline Lamps

Slimline—Butt-on Low Voltage
End Screw Terminal Type
for Slimline Lamps

- Sylvania's complete line can provide the exact lamp holder or starter socket to meet your requirements.

These wiring devices are carefully manufactured to Sylvania's exacting standards, and are approved by Underwriters' Laboratories and Canadian Standards Association Approvals Laboratories.

When you need the best in fluorescent wiring devices, see Sylvania. For complete details and specifications, write for catalog.

Slimline Fixtures High Voltage End
Screw Terminal Type
for Slimline Lamps

Slimline Fixtures Low Voltage End
Screw Terminal Type
for Slimline Lamps

Medium—Separate
Lead Terminal Type

Medium—Butt-on
Lead Terminal Type
—with or without mounting bracket

**SYLVANIA** PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS · 4-way service from one source

design by mc Philben

**EDGE-LITS**—Smart new styling features . . . cast aluminum construction, satin finish . . . hinged access doors . . . Ask for the "45 line".

**SURFACE**—Cast aluminum, satin finish and hinged access doors . . . flush, almost invisible hardware . . . "sightline" inscription panels. Ask for the "40 line".

**RECESSED WALL**— Protective guards or shock-resisting panels . . . cast aluminum, satin finish . . . hinged access doors. Ask for the "54 line".

All fixtures available with special wording and 4", 6" or 8" letters with red, green and white color combinations.

1353 Willoughby Ave., Brooklyn 37, N.Y.

CONSULT mcPhilben Lighting SPECIFY

Representatives in major cities

# NEW EQUIPMENT DATA

## AVAILABLE WITH COUPON

**New manufacturers' catalogs and bulletins listed below are available free to readers of ILLUMINATING ENGINEERING by mailing the coupon. Circle the numbers of those items which you want, drop in envelope or fasten securely to back of 2-cent postcard addressed to Publications Office.**

**1** New MOHAWK series of shallow commercial fluorescent luminaires is described in 6-page, 3-color brochure providing general information on a new line especially designed for modern low ceilings. Brochure and fixture catalog pages give complete technical data, characteristics, etc. Sylvania Electric Products Inc., Wheeling, W. Va.

**2** 50-page catalog No. 10 shows complete line of industrial and commercial incandescent lighting fixtures and materials for electrical construction with complete illumination information and cross references to government specifications. Spero Electric Corp., Cleveland, O.

**3** Bulletin GEC-1403 on mercury vapor street lighting discusses the use of such lighting in all classes of streets and highways; describes line of company's luminaires; details technical data on photometric performance, light distribution, and dimensional diagrams of units. General Electric Co., Hendersonville, N. C.

**4** New 4-page brochure depicts new light control for stores and industry through use of directional reflector fluorescent lamp, provides genera linformation on new lamp with "built-in" reflector said to increase downward brightness by 60 per cent. Folder suggests various uses in markets, display cases, etc. Sylvania Electric Products Inc., Salem, Mass.

**5** Five new 4-page bulletins provide up-to-date, complete data on fluorescent light panels, containing graphs, sketches and illustrations to show the lighting engineer photometric data, specifications, illumination levels and product features at a glance. Corning Glass Works, Corning, N. Y.

**6** Traditional Catalog T shows company's complete line of traditional church and institutional lighting equipment, each design represented in a full color photograph with detail drawings of correlated units which make up the design relationship; gives information and special features of styles for every period of architecture. R. A. Manning Co., Sheboygan, Wis.

**7** Performance and specification data sheet shows company's #980 series downlights said to have 82% efficiency, using 300-500 w. R-40 lamp and containing all brightness within a 90-degree cone of light. Sheet shows output and spread at various ceilings heights and installation data. Century Lighting Inc., New York, N. Y.

**8** 36-page Bulletin B contains descriptions, illustrations and lighting data on 394 of company's industrial fluorescent lighting units, covering all types of industrial lighting systems and simplifying reference according to reflector types, lamp types, accessories, construction and lighting data. Benjamin Electric Mfg. Co., Des Plaines, Ill.

**9** New 8-page catalog and accompanying 6-page installation procedure booklet, numbered SK 556 and INS 50-56 respectively, describe new 24" square recessed units for 150 to 500 w. silvered bowl lamps; show various new designs and available diffuser bottoms. Skylike Lighting, Inc., Bound Brook, N. J.

***Offer good for two months***

***Circle numbers wanted. Enter name and address. Clip out and mail.***

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11 12 13 14 15 16 17 18 19

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Company_____

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**10** Folder No. 200 is a new catalog containing photographs, specifications and descriptive material on new DIRECT-THE-LIGHT incandescent units for providing auxiliary accent lighting for churches, public buildings and commercial installations. Novelty Lighting Corp., Cleveland, O.

**11** 12-page booklet CE-556 provides a new manual on short-arc lamps and their applications in searchlight, projection and optical service, presents complete technical data and operating instructions, as well as applications for mercury, mercury-xenon, xenon short-arc lamps. Westinghouse Lamp Division, Bloomfield, N. J.

**12** New 16-page, 2-color catalog presents in six sections, technical data, wiring diagrams, electrical and mechanical specification tables for company's line of lighting ballasts. Sola Electric Co., Chicago, Ill.

**13** No. 6024 CONTROLENS is described in 2-color, 4-page folder which shows applications of and technical data on new diffuser lens employing conical prismatic elements formed into a concave shape and having longitudinal and transverse fins. Holophane Co., Inc., New York, N. Y.

**14** Pocket-size, 12-page booklet GED-2416B contains cross reference information for general line, rapid-start, slimline, instant-start and circline 60-cycle ballasts as well as comparative data on all ballasts. General Electric Co., Schenectady, N. Y.

**15** Folder explains company's six different types of luminous ceilings, with emphasis on their ACUSTI-LUMINUS, MODU-LUMINUS, and ELECTRIC-LUMINUS systems; shows installation and characteristics details and complete specifications. Luminous Ceilings Inc., Chicago, Ill.

**16** Bulletin TH-56 is a new, illustrated 8-page booklet covering the company's line of automatic, adjustable fixture hangers and accessories for indoor applications; illustrates typical installations and explains principles of patent mechanism which permits floor-level maintenance for high lighting installations. Thompson Electric Co., Cleveland, O.

**17** New 4-page booklet supplies data for lighting engineers on new PYREX brand square concave LENSLITE; gives recommended optical systems, brightness and distribution data, coefficients of utilization and illumination characteristics. Corning Glass Works, Corning, N. Y.

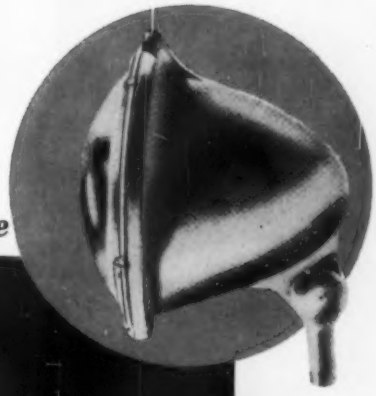
**18** Forms Nos. 955, 956, 957 provide complete information on eight new models of 2′ wide recessed troffers for installation in 83 different ceiling systems, available in 2-, 3- and 4-light units in 2′ and 4′ lengths. Edwin F. Guth Co., St. Louis, Mo.

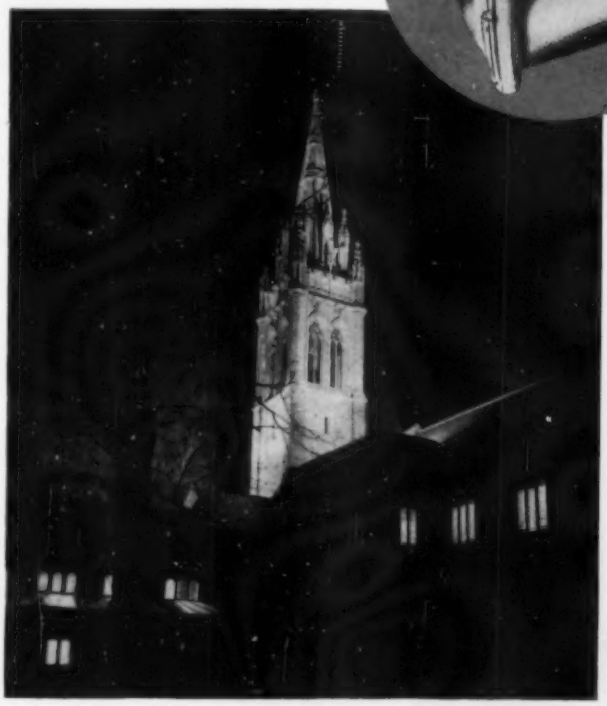
**19** New LF folder shows custom-designed fixtures, lanterns and lamp standards, both contemporary and traditional, for offices, public buildings and churches. Meierjohan-Wengler, Cincinnati, O.


# ILLUMINATION

## BY MAGNI FLOOD

*Enhances Church Spire*





Installation by Lawrence Electric Service, Newton, Mass.

**The graceful beauty of the Second Congregational Church in Newton, Mass. "now stands revealed in all its delicate strength each evening," through the use of Magni Flood quality outdoor lighting equipment.**

**Faced with the problem of effectively lighting this impressive edifice, the contractor turned immediately to Magni Flood. 16 Magni Flood Catalog "Y" fixtures (installed on the ground – 4 on each side of building) used with 500W PAR 64 lamps (2 wide floods, 1 medium flood, 1 narrow spot) supplied the answer to this challenging job of outdoor lighting.**

*MAGNI FLOOD*

INCORPORATED

38 NORTH SECOND AVENUE • MOUNT VERNON, N.Y.

MOUNT VERNON 8-1385

Manufacturers of a complete line of outdoor floodlights and accessories.

In Canada, a Division of Wakefield Lighting Ltd., London, Ontario.

**MAN: fire loving animal**

We'd like to add to the famous remark about man being a tool making animal . . . he is also a fire loving animal — not just for its warmth, but for the quality of its radiance. In modern lighting, the heated tungsten filament gives us something like the light of the fire . . . warm and colorful and lively. To control the radiance of small heated filaments, Century makes the widest variety of engineered instruments to give you the right quantity and quality of light.

**CENTURY**
**LIGHTING, INC.**
521 WEST 43rd ST.
NEW YORK 36, N. Y.
1820-40 BERKELEY ST.
SANTA MONICA, CALIF.
1477 N.E. 129th ST.
N. MIAMI, FLORIDA

CAN


*(Continued from page 26A)*

Falk, A. F., Wisconsin Electric Power Co., Milwaukee, Wis.

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Gaudette, G. M., Sylvania Electric (Canada) Ltd., Drummondville, Que.
Gervais, J. W., 1100 DeLaTerriere St., Trois Rivieres, Que.
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LeBlanc, G. J., Canadian General Electric Co., Montreal, Que.
Lemire, Edgar, J. S. Ducharme Engineering, Shawinigan Falls, Que.
Lilley, N. E., Rodnor Electric Inc., Shawinigan Falls, Que.
Phillips, C. A., Arthur Lacourceere, Shawinigan Falls, Que.
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Moffat, A. C., Portland General Electric Co., Beaverton, Ore.
Rawson, J. F., Sylvania Electric Products Inc., Seattle, Wash.
Wall, H. L., The Sloan Co., Medford, Ore.

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### Suwannee River Chapter

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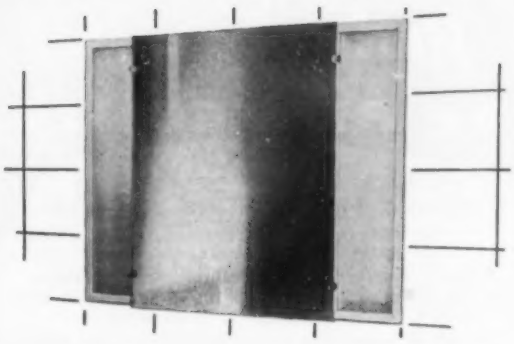
Evans, W. B., Savannah Electric & Power Co., Savannah, Ga.

*(Continued on page 46A)*

# MILWAUKEE FLUORESCENT BATHROOM CABINET



## For Perfect Bathroom Lighting

Bathrooms are *sure to please* when you specify this outstanding combination.

*Four 20-watt fluorescent* lamps, behind Corning Alba-Lite opal glass, provide glareless, shadowless illumination. No other light needed in most bathrooms.

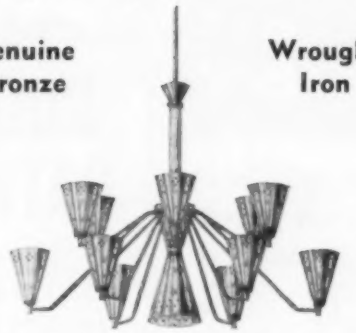
Roomy cabinet has high-quality polished plate glass mirror, polished-edge glass shelves. All-welded 20-gauge cold rolled steel construction with double-baked white lifetime enamel finish. Fits 30⅛ x 24⅛ x 4 in. wall opening.

***See your electrical wholesaler or write for Bulletin 381.***

**NORTHERN LIGHT**
COMPANY

# *Ornamental Lighting Fixtures*

**Genuine Bronze** **Wrought Iron**



We are "just your size"—big enough to produce any lighting-fixture job, however intricate or extensive; small enough to give every job our personal attention and supervision, and to produce lighting equipment of the finest character in every detail.

***Estimates and literature sent on request.***

**MEIERJOHAN-WENGLER**
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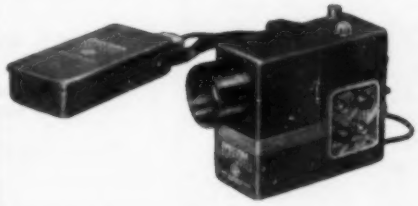

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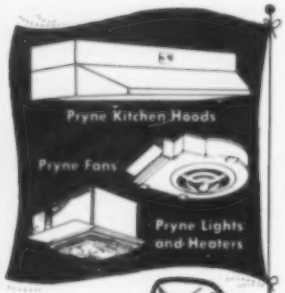


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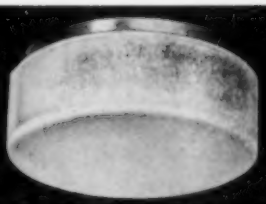

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Fixtures are Underwriters Laboratories, Inc. approved. *Patent pending.

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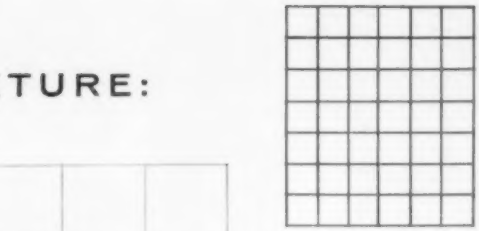
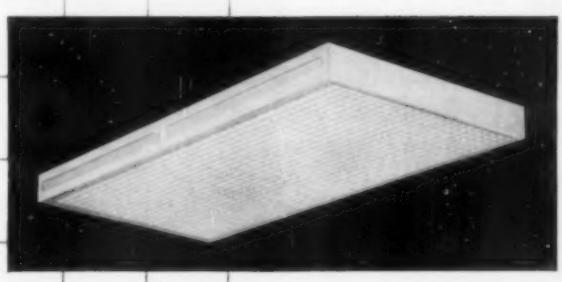


8 sq. feet of unobstructed illumination



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**LONG BALLAST LIFE • TROUBLE-FREE OPERATION**
**FREEDOM FROM NOISE**

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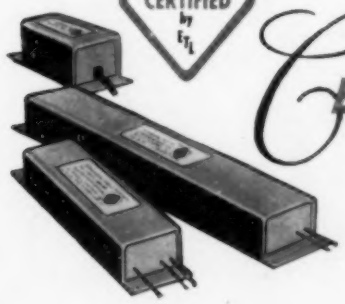

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